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STUDY OF THE PROTECTION OF THE TITANIUM BOLT ASSEMBLY

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Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

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STUDY OF THE PROTECTION OF THE TITANIUM BOLT ASSEMBLY

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RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	α	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Υ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ	κ ϰ	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

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TITLE: Study of the protection of the titanium bolt assembly

AUTHOR: G. Sertour - M. Guerlet

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22 Nov 1973	14.310.230/FINAL	27	14	

AUTHOR'S SUMMARY: The finishing presently used on the T-A6V bolt assembly—anodic sulfuric oxidation, lubrication with molybdenum bisulfate, is inconvenient in certain respects; in particular, from the point of view of corrosion of the poles by galvanic couples and adhesion of paints and mastics on the screw heads.

The tests consisted of comparing various possible methods of protection, encountered during tests defined according to various norms.

Among the tested protective agents, MoS_2, Cadmium and Aluminum, only the aluminum protection agent gave results which were satisfactory in all respects.

INDEX NOTATION:

MINUTES NO. 14.310.230/FINAL

STUDY OF THE PROTECTION OF THE BOLT ASSEMBLY T-A6V

TASK STAe 72-94-336 LOT No. 9

LET BY THE TECHNICAL AERONAUTICAL SERVICE, MATERIALS SECTION

M. Guerlet and G. Sertour*

1. General Remarks

The lifetimes of commercial aircraft depend to a large extent on the resistance of structures to fatigue and various corrosion phenomena.

The elements for attachment play an essential role in this problem because they condition the fatigue resistance of various assembled parts. Since they are present in nonprotected areas, in certain cases they can provoke corrosion phenomena because of galvanic couples.

Titanium bolt assemblies, used extensively in modern aircraft, are presently being used with various finishes by various manufacturers:

*National Industrial Society, Aerospace. Quality Control Directorate. Central Laboratory, Gv. Surennes, November 22, 1973.

unplated or cadmium plated in the United States, material with anodic sulfur oxidation in Germany, and material with anodic sulfur + MoS_2 oxidation in France.

Each of these finishes has its drawbacks:

— weakening of the cadmium plated bolt assembly under hot conditions;

— requirement for "humid" assembly for naked bolt assemblies in order to avoid corrosion caused by galvanic couples;

— acceleration of the corrosion of structures, poor adhesion of paints, poor electrical continuity in the case where titanium bolt assemblies protected with OAS + MoS_2 are used.

Recently, a solution has been proposed: protection using aluminum deposition.

The aim of the proposed tests was to compare the performances of the various aluminum protection methods advanced by the manufacturers and the performances obtained with solutions utilized up to the present or which seem promising.

2. Protection Methods Tested

2.1. Molybdenum Bisulfate on Anodic Sulfur Oxidation

Three different types of MoS_2 were tested:

— M 88

— X 106 on a resin base which can be heat-hardened

— Emos 60.

2.2. Graphite Base Varnish on Anodic Sulfur Oxidation

— D 81 bis "Anderol"
thermostable lubricating varnish on a graphite lamella base.

2.3. Cadmium deposited electrolytically, without bichromium treatment.

2.4. Aluminum

At the present time, there are two reference standards in the United States: NAS 4006 and AMS 2506 A for organic resins.

Three protection agents conforming to the NAS 4006 were tested:

— VSM 1368 proposed by VOI-SHAN

— VERTEC ALCOTE (practically identical with VSM 1368)

— HI KOTE 1 proposed by HI-SHEAR.

These different protection agents are made of organic resins containing aluminum powder deposited by immersion (VSM 1368) or by pulverization. They contain corrosion inhibitors in the form of chromates and phosphates.

A single protection agent conforms with the AMS 2506 A and was proposed by S P S: SERMETEL W, which is an inorganic resin also containing chromates and phosphates, which improve the corrosion resistance, as well as the adherence.

At the present time, the production method for these products has not been divulged.

3. Tests Performed

The tests were partially or completely performed with each of the protection agents given above. The complete collection of tests mentioned above, as well as their results, are contained in the summarizing table on page 16.

3.1. Measurement of Protection Agent Thickness

The control of the thickness and quality of deposition was done using an optical microscope with longitudinal sections of the bolts.

The thicknesses measured on screws protected with aluminum are the following:

- SERMETAL W: 5 to 40 microns, very irregular deposit
- VSM 1368: 10 to 15 microns within a lot
  6 to 8 microns within another lot
- VERTEC ALCOTE: 4 to 5 microns

The photographs are given in plate 1.

3.2. Adherence Tests

3.2.1. Of aluminum protection agent

The adherence tests were carried out on T-A6V sheets, protected according to norm NFT 30038 before and after aging in a humid oven for 750 hours at 40° C, HR 98%.

These adherence tests were carried out also in order to verify the resistance of the protection agents after immersion in various media: hydraulic fluid, kerosene, paint solvents, etc.

3.2.2. Of the paints

3.2.2.1. Samples

The samples consisted of the following:

— T-A6V sheet protected by the covering being tested and with a primary epoxy ICI 2022 coat of paint (primary TSS)

— or of a A-U2GN block in which the protected bolts were installed, and the complete assembly was covered with the same primary coat.

3.2.2.2. Tests

The tests were carried out under the same conditions as in 3.2.1.

3.2.3. Of sealing products

The peeling tests were carried out on T-A6V sheets protected and painted again with PR 1431, according to the norm MIL S 8802 D.

3.3. Results

The results are summarized in the following table:

Protection Agents	Adherence of Paints		Adherence of PR 1431
	Before aging	After aging	
T-A6V blank	100%	100%	
OAS + M 88	0 to 15%	0	100%
OAS + X 106	0 to 20%	0	0
OAS + EMCS 60	100%	0	100%
OAS + D 81 bis	100%	100%	20%
SERMETEL W	100%	100%	100%
VSM 1368	100%	100%	100%
HI KOTE 1	100%	100%	100%
VERTEC ALCOTE	100%	100%	100%

In all cases, the adherence of the paints and of the sealing product on the aluminum protection agents and on the bolt assembly is 100%. No type of molybdenum bisulfate gave satisfactory results in any of these tests.

The photographs of plates 2 to 5 show the samples after the tests.

3.4. Couple-Stress Relationship

It is established using a strain gauge transducer and the couples are applied using the dynamometer key.

The results are given in graphs on pages 17 through 25.

The acceptance of the aluminum protection on the titanium bolt assembly will not lead to any modification of the tightening couple values established by the screw assembly protected with type M 88 OAS + MoS_2.

3.5. Measurement of Installation Force

In order to improve the fatigue performance of the assembled parts, at present the tendency is to mount the fixation devices with interference.

One important aspect from the fabrication point of view is the ease of installation.

This was determined by measuring the maximum necessary force required to install screws in the A-U2GN T 651 blocks.

For all the test cases, the holes were machined so that an interference of 60 ± 5 μ was obtained.

These tests were carried out on an Instron traction machine in order to determine the maximum forces. A few tests which simulate the aircraft configuration conditions were also carried out using a multi-strike tapping machine and with a mallet.

We were able to establish the following comparisons based on the availability of the screws according to their protection agents:

1) VSM 1368
SERMETEL W — lubricated with cetyl alcohol
HI KOTE I

with screw HI TIGUE HLT 410-8-16 (diameter 6.35, thread length 25.4 mm).

2) VSM 1368 lubricated with cetyl alcohol
OAS + MoS_2 (M 88)

with screw NSA 5040 V-4-12 (diameter 6.35, thickness of thread 19.05 mm)

3) T-A6V without covering, lubricated with cetyl alcohol OSA + MoS_2 (m 88) with screw HI TIGUE HLT 410-8-12 (diameter 6.35, thread thickness 19.05)

4) VSM 1368
SERMETEL W — nonlubricated screw
HI KOTE I

with HI LOK NSA 5040 V-4 (diameter 6.35).

After installation of the parts, certain blocks were cut in order to extract the screw without introducing additional damage to that caused by the configuration.

The photographs of plates 6 to 8 show the screws before introduction, after introduction, and after installation and disassembly.

The results of th ͻ tests are given in the form of tables on pages 14 and 15.

One would expect that the smallest installation forces could be obtained using the type HI KOTE I aluminum protection.

In effect, one can take into account the values obtained with the SERMETEL W. During installation, the thickness of the covering was increased from 40 to 20 μ by lamination.

In addition, for this same protection, the measured diameter is excessive compared with the average edge, because of the irregular nature of the deposit.

3.6. Resistance to Solvents, Primary Coat, Paint, Kerosene

The bolts were immersed for 24 hours in the following liquids at ambient temperature:

— isopropyl alcohol

— methyl-ethyl-cetone

— 850 - 805 dilution agent of the primary ICI 2010

— JP1 kerosene.

An adherence test was then made for the bolt heads according to norm NF T 30038.

For the four types of aluminum deposits, we obtained 100% adherence.

3.7. Resistance to Hydraulic Fluids

These tests were carried out on a T-A6V sheet which was protected. Three fluids were used: F H S, Oronite M2V, and Skydrol LD.

The test was carr i out after 30 days of immersion at 70° C and resulted in 100% adherence for all the aluminum protection agents.

3.8. Resistance Tests Against Galvanic Couple Corrosion

The bolts were mounted on A-U2GN T 651 blocks after having been subjected to the primary TSS protection range.

The following tests were performed:

— 1500 hours in saline vapor, according to norm NF X 41-008

— alternate immersion and withdrawal (50' — 10') for 1500 hours

— with natural corrosion at Ile du Pilier for one year

— in acetic saline vapor for 14 days, according to ASTM B 287 modified according to NAS 4006 (the tests were only carried out for aluminum protection agents).

For the various test cases, the aluminum protection agents always resulted in better results than the naked bolt assembly protected with OAS + MoS_2 (M 88).

In the case where the naked bolt assembly was installed, an aluminum oxide deposit is formed between the bolt and the drill holes, which makes it impossible to manually disassemble the screw.

Type X 106, EMOS 60, and D 81 bis varnishes considerably accelerate the galvanic couple corrosion, especially X 106.

The classification of the protection agents from the point of view of resistance to corrosion is identical for the various test modes, and the saline vapor is the most selective.

It seems that we have the following decreasing sequence:

— VSM 1368

— HI KOTE - SERMETEL W and VERTEK Alcote

— T-A6V naked an '-A6V protected by OAS + M 88

— EMOS 60 and D 81 bis varnish

— X 106 varnish

A few installation photographs after the tests are given in plates 9 through 12.

3.9. Weakening Tests

These tests were carried out on bolts and nuts made of tempered T-A6V, with heads milled to 100°.

The screws were mounted on 25 CD4 blocks and subjected to prestresses equivalent to 70% of the true fracture load of the screw.

These assemblies were then placed in a dry oven at temperatures of 100 or 150° C, for times which varied between 24 hours and three months.

After the tests, the bolts were disassembled and examined under the microscope and longitudinal sections were made in order to detect and measure the cracks. We made the following observations:

— the blank screws or the screws protected by OAS + MoS_2 and the screws protected by aluminum are not weakened after three months of tests at 150° C.

— on the other hand, the cadmium plated titanium screws cracked after 24 hours at 100° C. The results are given in the form of a curve: length of crack — aging time — temperature: page 26.

The photographs on plates 13 and 14 show the cracks obtained with cadmium plated screws.

3.10. Heat Resis ıce

The tests for adherence of the protective agents according to the norm NF T 30038 were carried out on T-A6V sheetmetal, which was protected, after exposure to 235° C for four hours or to 200° C for 1000 hours.

For these two test cases, we obtained 100% adhesion with the four aluminum protection agents.

3.11. Assembly Fatigue Tests

We utilized two types of samples which had been previously tested during the fixation tests, HUCKRIMP - KAYLOBE HY LOK (cf., PV 34.521). The diagrams for these samples are given on page 30.

The samples were assembled with HI LOK screws of the type NSA 5040 V 3-5 (Ø 4.81 — length 7.94 — head F 100°), as well as NSA 5040 V 4-6 (Ø 6.35 — length 9.52 — head F 100°) which was protected by VSM 1368 and the nuts HI LOK NSA 5075-6 and 8 (aluminum alloy 2024 nuts).

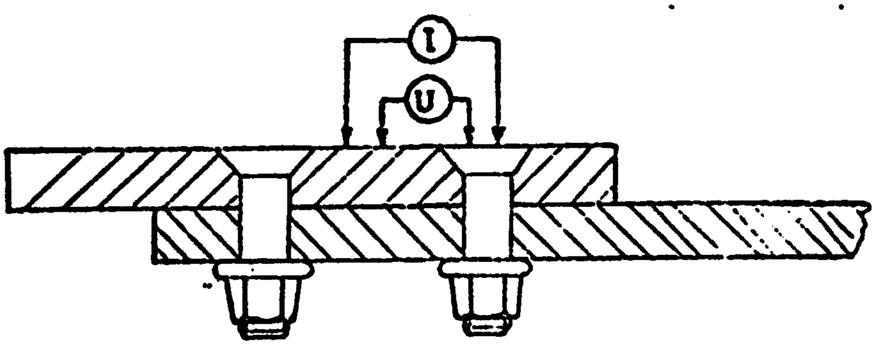
The elements were installed with an interference of 20 μ on type "D" samples and the clearance was 25 μ for type "G" samples.

The tests were carried out with varying forces F — 0.1 F. The corresponding loadings were a net stress of 13 hbar — 1.3 hbar. The results are given on pages 27 and 28.

The results are identical as far as Ø 6.35 is concerned, to those obtained with KAYLOBE + steel nut or HUCKRIMP + T-A3V2.5 nut. They are slightly superior to those obtained with the HI LOK finished with OAS + MoS_2 for the Ø 4.8.

3.12. Contact Resistance

These tests were carried out with dynamic test samples. The diagram for measuring this with the micrometer is as follows:



I constant 40 mA

The results are compared with those obtained previously on the aircraft or with the samples, page 29.

It appears that, among the four aluminum protection agents measured, only the SERMETEL W gives contact resistances which are comparable with those obtained with the T-A6V, either blank or cadmium plated.

One should note the large dispersions obtained with the protective substance OAS + M 88 and the aluminum protective agent VSM 1368. The values obtained have the same order of magnitude.

The HI KOTE I protective agent seems to result in higher values. In order to obtain significant values, these tests should be carried out with a larger number of samples if this cannot be done on an aircraft.

4. Conclusions

Looking over the results of all of the tests, it can be seen that all of the aluminum protection agents give results which are superior or at least equivalent to those obtained with molybdenum bisulfate.

These results are especially favorable for protecting aluminum for adherence tests for paints and mastics, as well as for corrosion and installation tests with interference.

For the aluminum protection agents, VSM 1368 gives results which are slightly superior.

Finally, given the inconveniences encountered during these tests by using other solutions:

— corrosion of drill holes with the blank bolt

— weakening with cadmium,

it seems that the aluminum protection method is the one with the highest "performance" and that it could be considered as a replacement for the present solution.

INSTALLA[illegible]ON FORCE (LUBRICATED SCREWS)

VIS HLT 410-8-16					
SERMETEL W e = 40 µ		VSM 1368 e = 10 µ		HI KOTE 1 e = 5 µ	
Interference	Force	Interference	Force	Interference	Force
54 µ	210 daN	60 µ	1040 daN	61 µ	850 daN
55	150	66	1390	64	1030
56	250	64	1040	63	1000
55	210	63	1070	52	870
55	200	61	1210	63	850

VIS NSA 5040 V-4-12	
Interference 60 µ ± 5	
VSM 1368	OAS + MoS_2 (M 83)
765 daN	785 daN
705	1225
920	1530
780	1290
755	1100

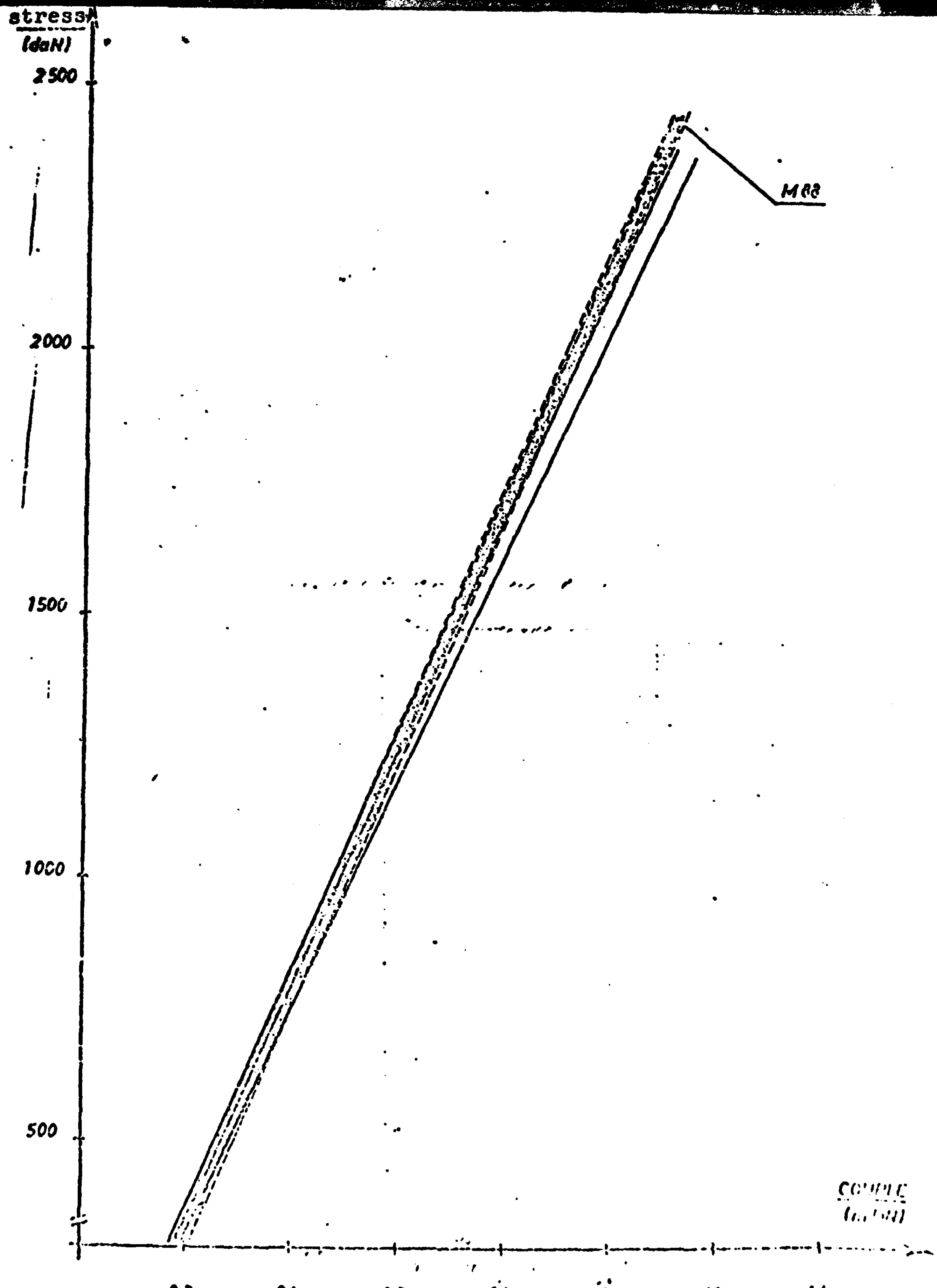
VIS HLT 410-8-12	
Interference 60 µ ± 5	
T-A6V nu	OAS + MoS_2 (M 83)
1940 daN	1760 daN
3200	1840
1670	1610
2230	2090
2160	1910

INSTALLAT[illegible] FORCE (NONLUBRICATED SCREWS)

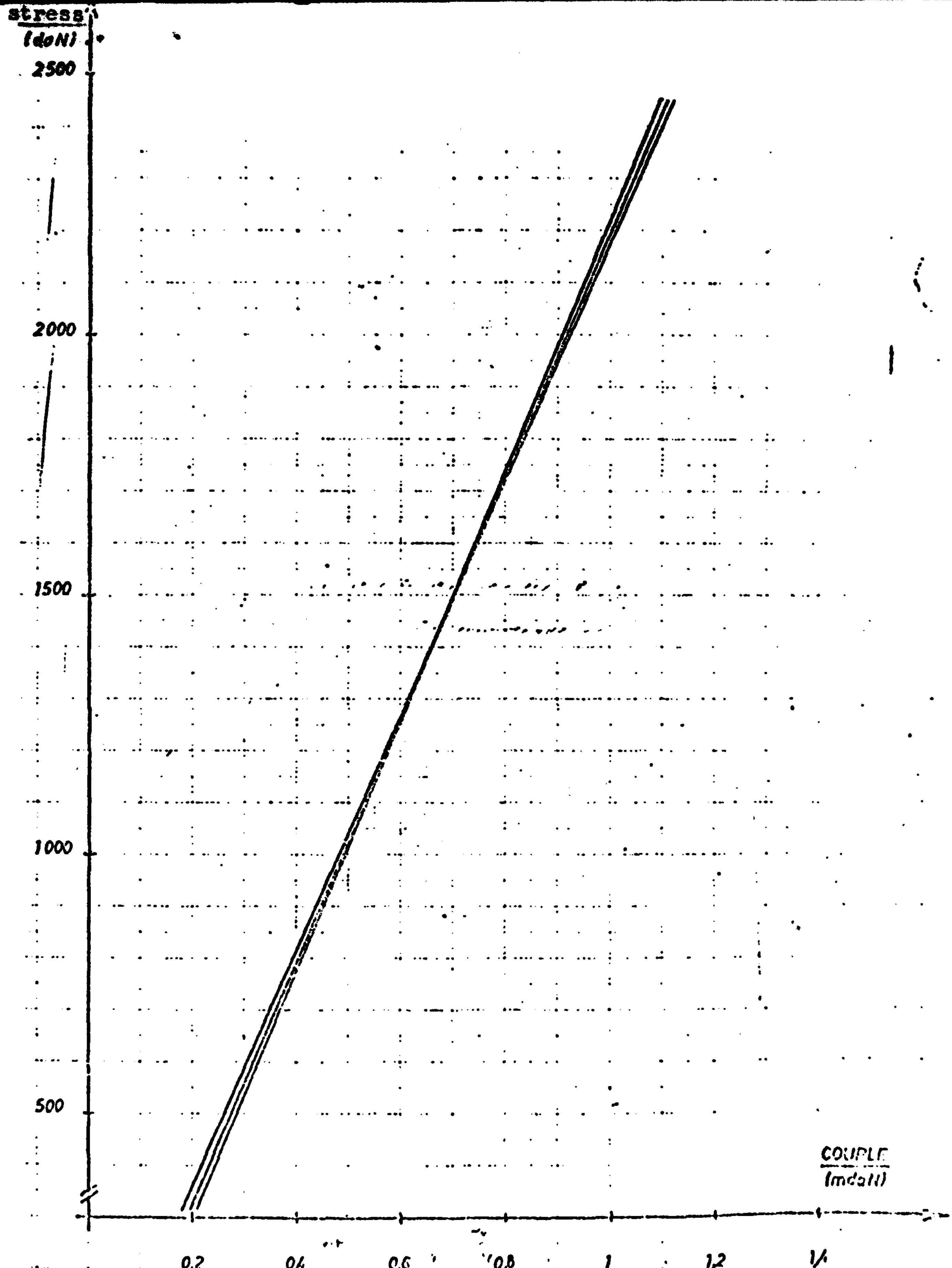
VIS NSA 5040 V-4-12					
SERMETEL W		VSM 1368		HI KOTE 1	
Interference	Force	Interference	Force	Interference	Force
43 u	530 daN	50 u	3680 daN	79 u .	1710 daN
41	360	55	4050	70	1620
41	420	59	3900	71	1710
		52	4000		

SUMMARY TABLE OF TEST RESULTS

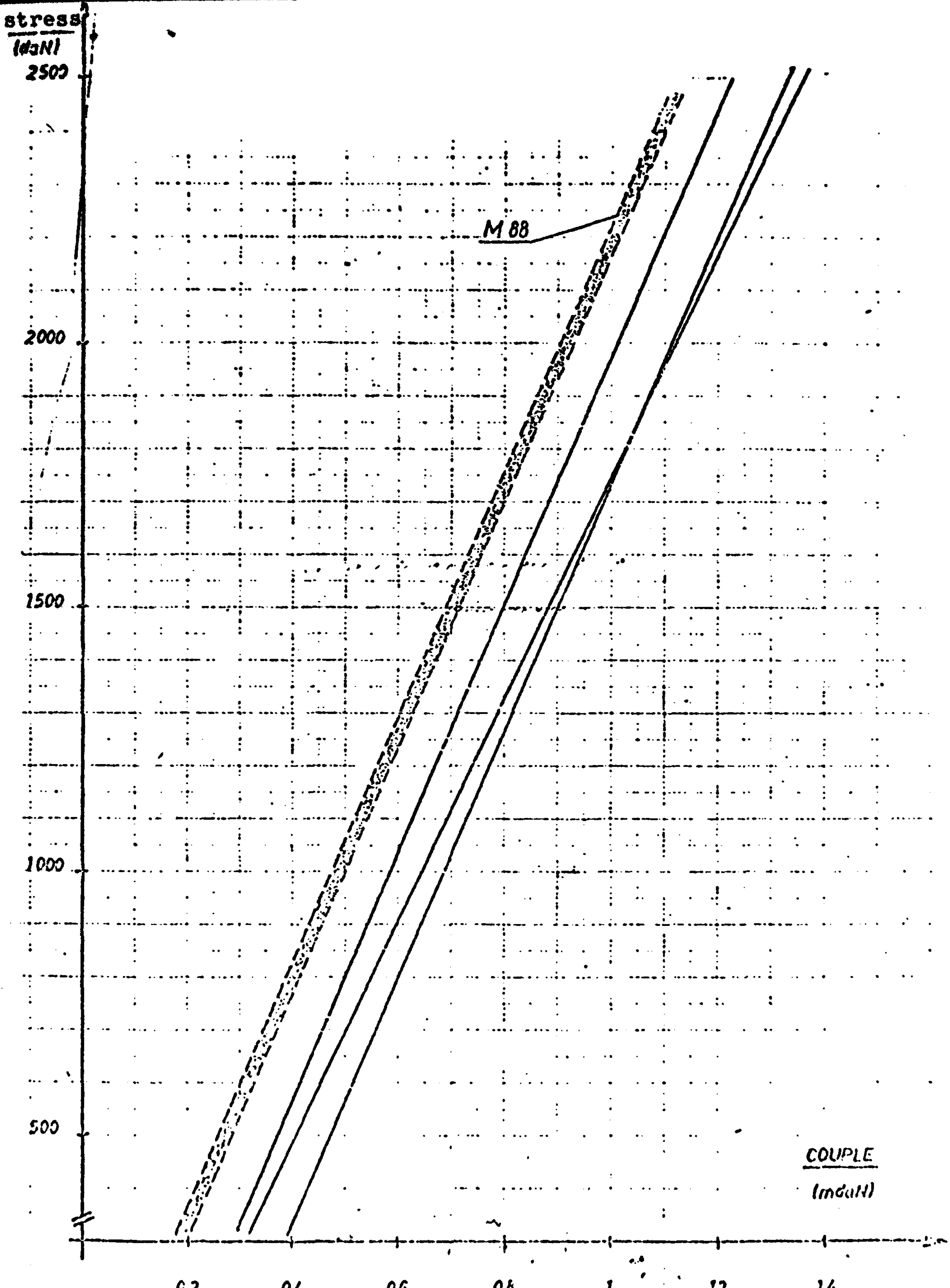
TESTS CARRIED OUT			TA 6 V NU	TA6 V+OAS MoS_2 (M88)	TA6V + Protection Aluminium NAS 4006: HI KOTE 1	VSM 1358	VERTEC	AMS 2506 A SERMETEL W
Thickness of protections				no stub indexing of the shaft	6 to 15 µ	5 to 20 µ	4 to 5 µ	5 to 6 µ (AMS 2506 A: 8 to 15 µ)
Adherence of protective agents. Without aging, by checkering NFT 30038					100%	100%	100%	1(
Adherence	Primary paint ICI 2022	Without aging	100%	0 to 15%	100%	100%	100%	1(
		750 h. 40°C 95% HR	100%	0	100%	100%	100%	100%
	Mastic 1431	Without aging	100%	100%	100%	100%	100%	100%
		750 h. 40°C 95% HR	100%	100%	100%	100%	100%	100%
Resistance of the protection agent with respect to fluids	Hydraulic 30 j. 70°C	7H3 Oronite H2V Skydrol LD			100%	100%	100%	100%
	Kerosene imersion at θ	J P 1			100%	100%		100%
	Solvants 24 h.at 250°C	MEK isopropyl alcohol		poor	good	good	good	good
	Diluting agent 24 h. to 250°C	850 805		poor	good	good	good	good
Installation force	Lubrication 150 gr/liter		2200 daN (HLT)	1500 - 1200daN (HLT) (HL)	900 - 550 daN (HLT) (HL)	1700-750.550daN (HLT) (HL)		200 - 400 daN (HLT) (HL)
	No lubrication				1700 daN (HL)	3500 daN (HL)		400 daN (HL)
Removability					Yes. one time with the press if lubricated Ø 6.35			yes. one time Ø 6.35
Resistance of the protection agent to heat (NFT 30038)	4 hours at 235° C				100%	100%	100%	100%
	1000 hours at 200° C				100%	100%	100%	100%
[Illegible]	[Illegible] R 150° C, 90 days		R.A.S	R.A.S	R.A.S	R.A.S	R.A.S	R.A.S
Corrosion	R.A.S		poor corrosion, drilling	poor corrosion, drilling				
	Natural corrosion				good	good	good	good
	Saline vapor							
[Illegible]				See graph page				
[Illegible]			1	1				0,7
[Illegible]				1	1	1		
[Illegible]	With lubrication		1		1	1	1	
	Without lubrication		0,9		0,9	0,9		0,9



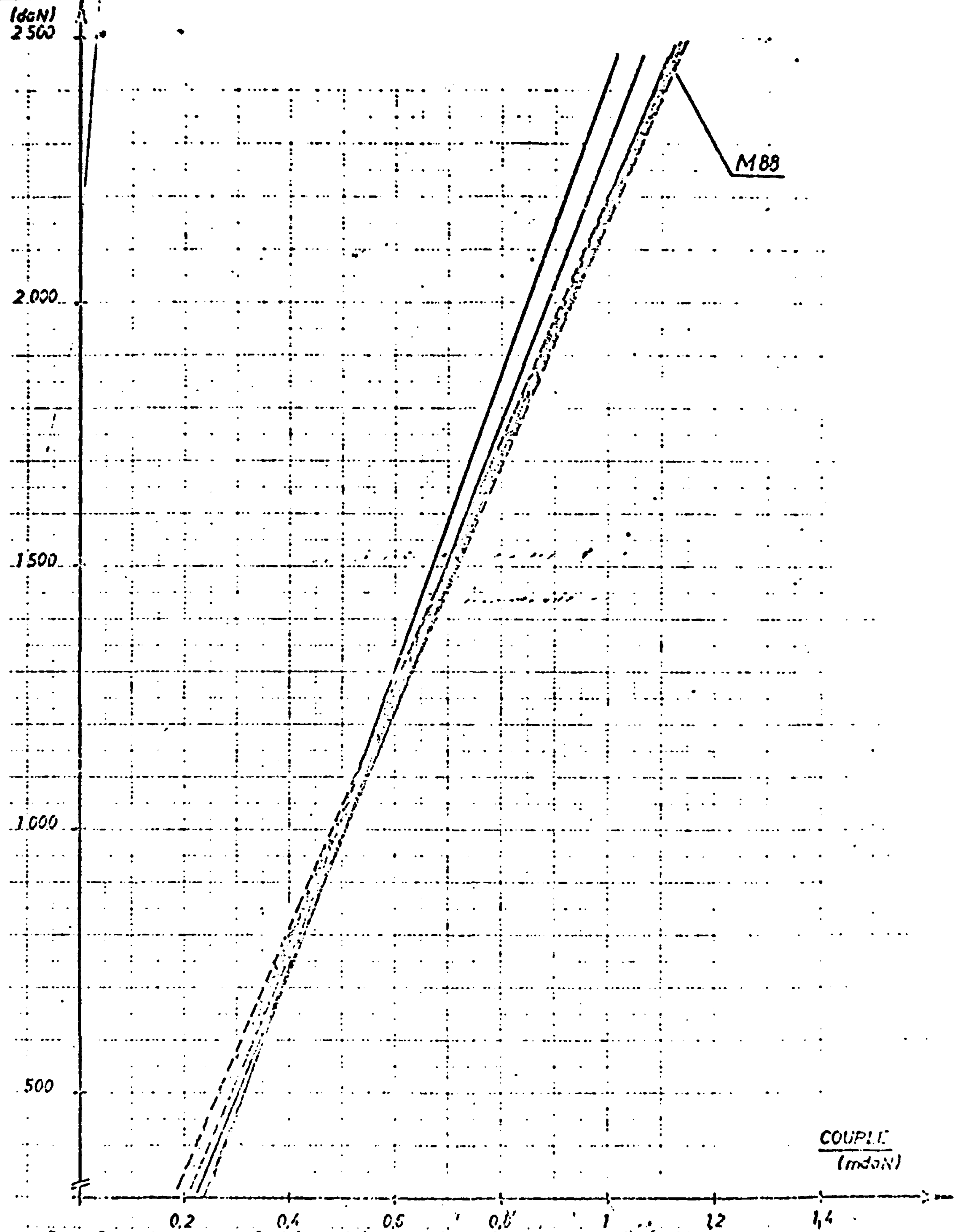
Couple-stress relationship: titanium screw Ø 6.35 NUE; lubrication: cetyl alcohol; steel cadmium nut, lubricated with cetyl alcohol.



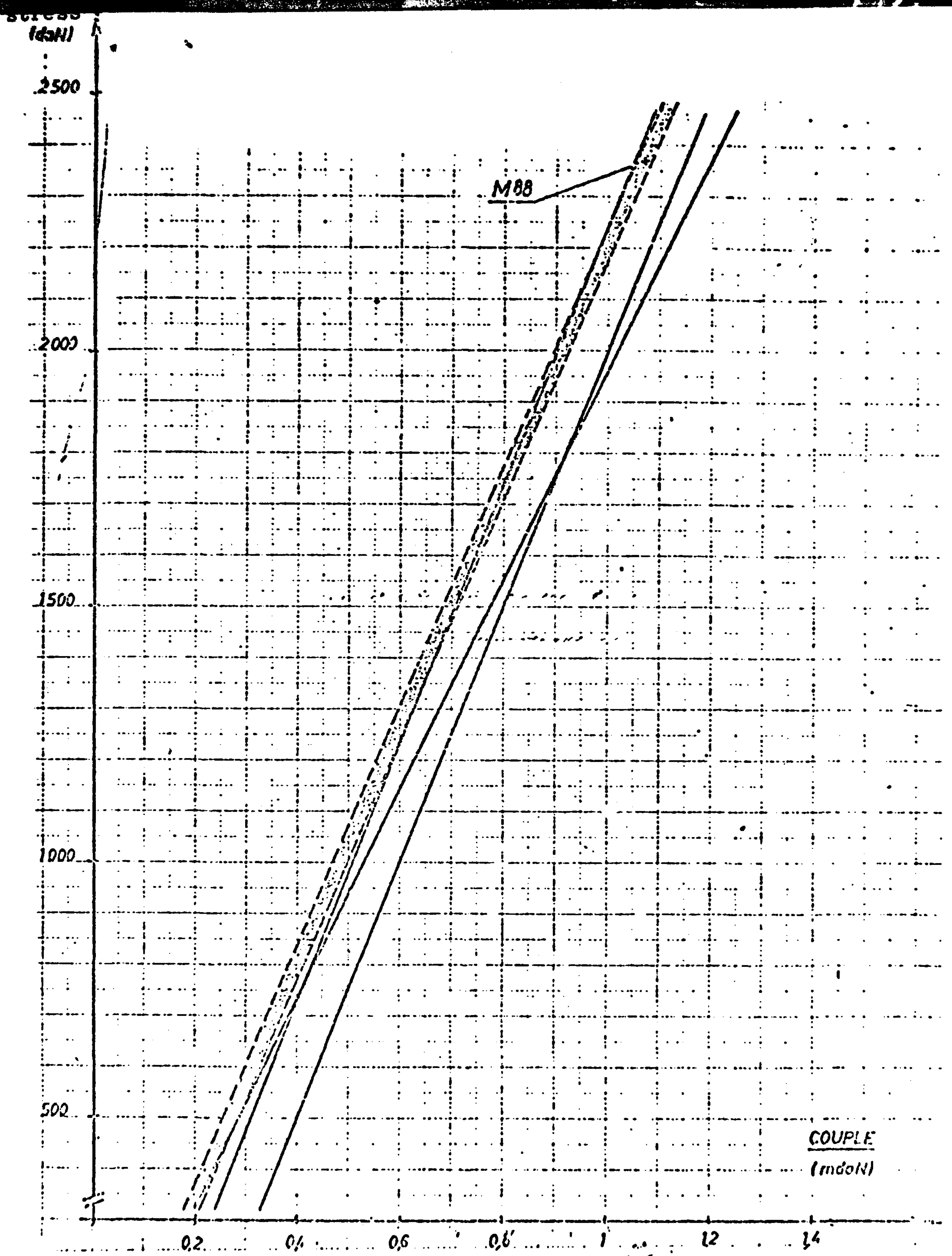
Couple stress relationship: titanium screw Ø 6.35, protected with O.A.S.; lubrication: MoS_2 M88; steel cadium screw, lubricated with cetyl alcohol.



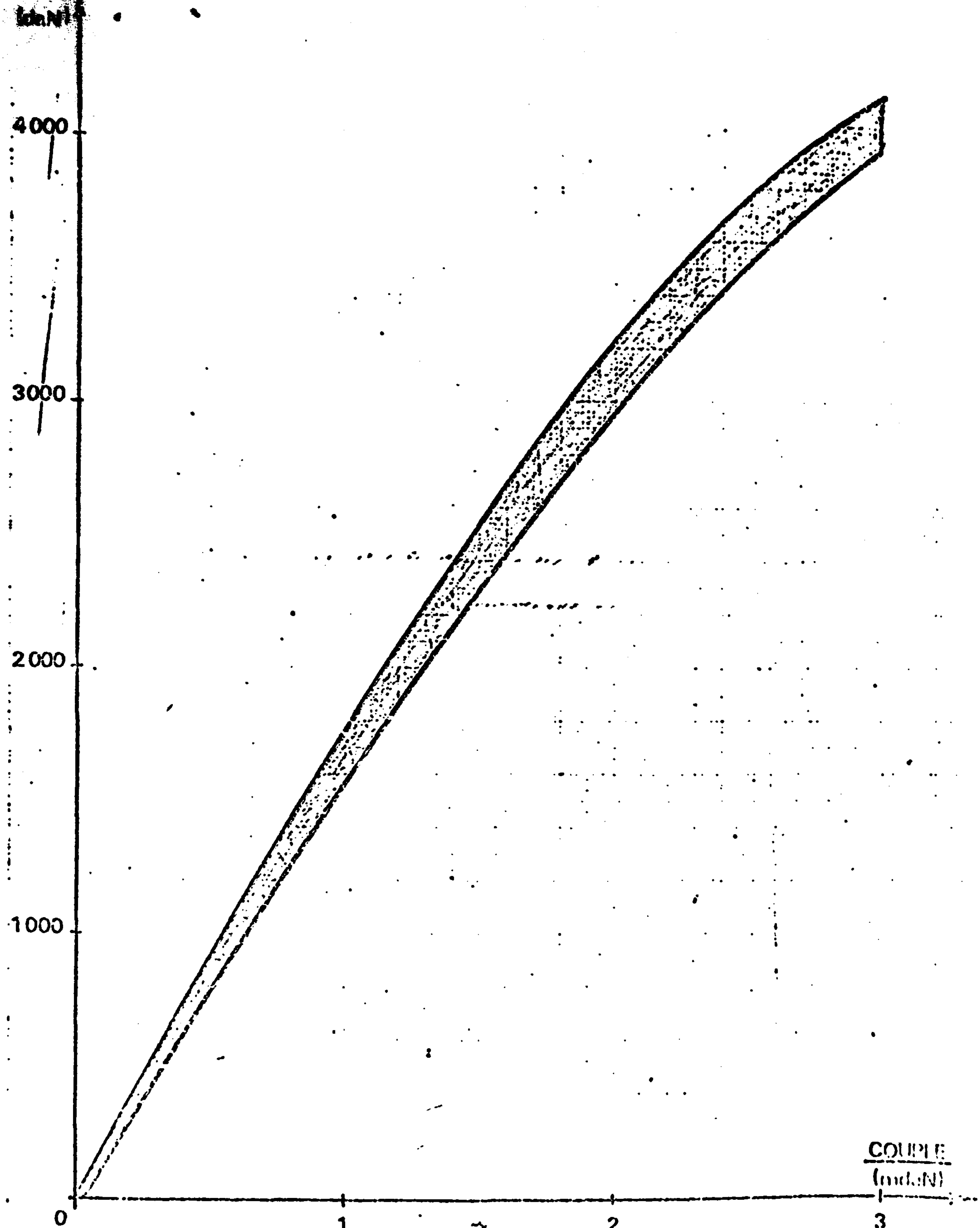
Couple-stress relationship: titanium screw Ø 6.35, protected with aluminum VSM 1368; lubrication: cetyl alcohol; steel cadmium screw, lubrication: cetyl alcohol.



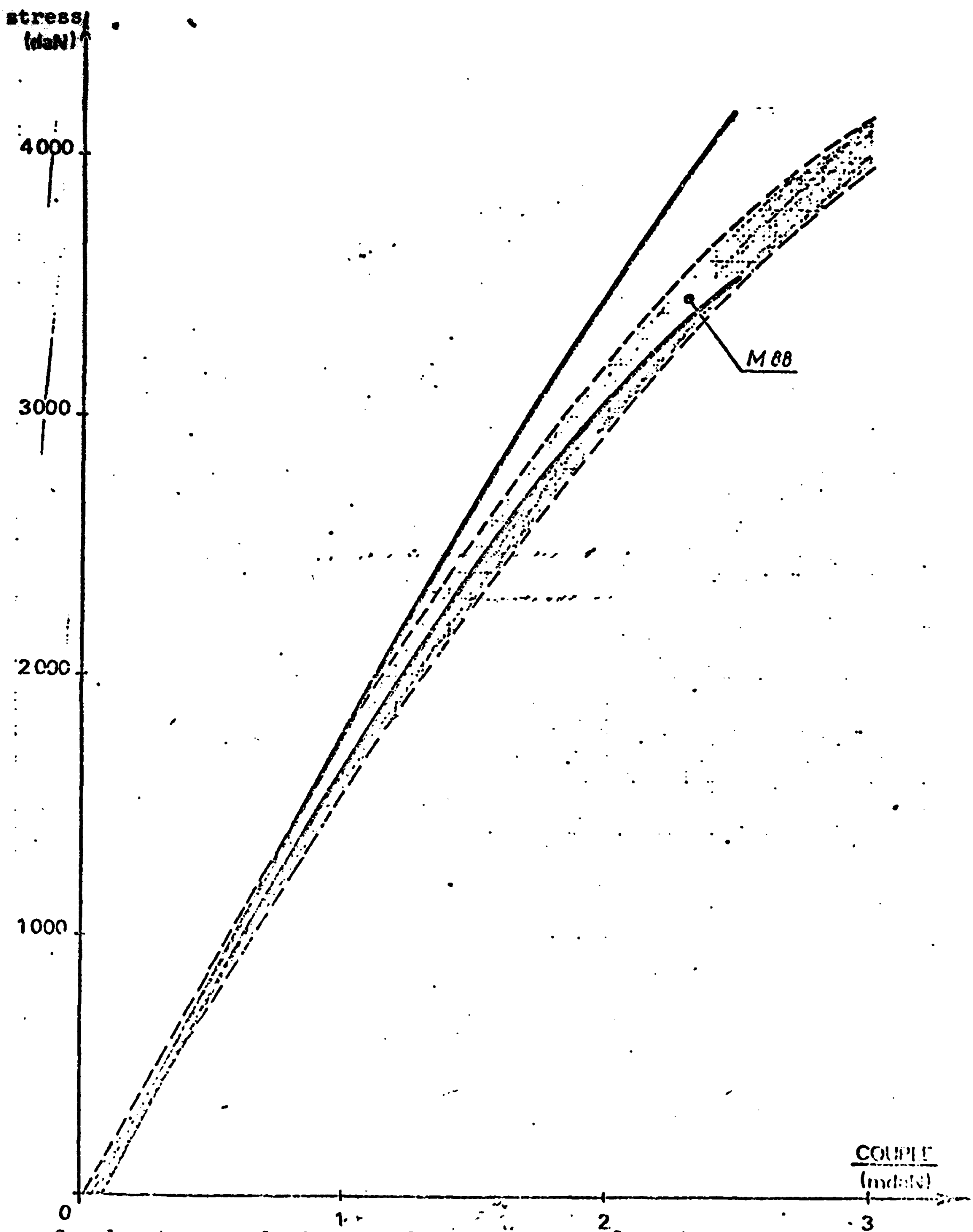
Couple-stress relationship: titanium screw Ø 6.35 protected with aluminum Sermetel W; lubrication: cetylic alcohol; steel cadmium screw, lubrication: cetyl alcohol.



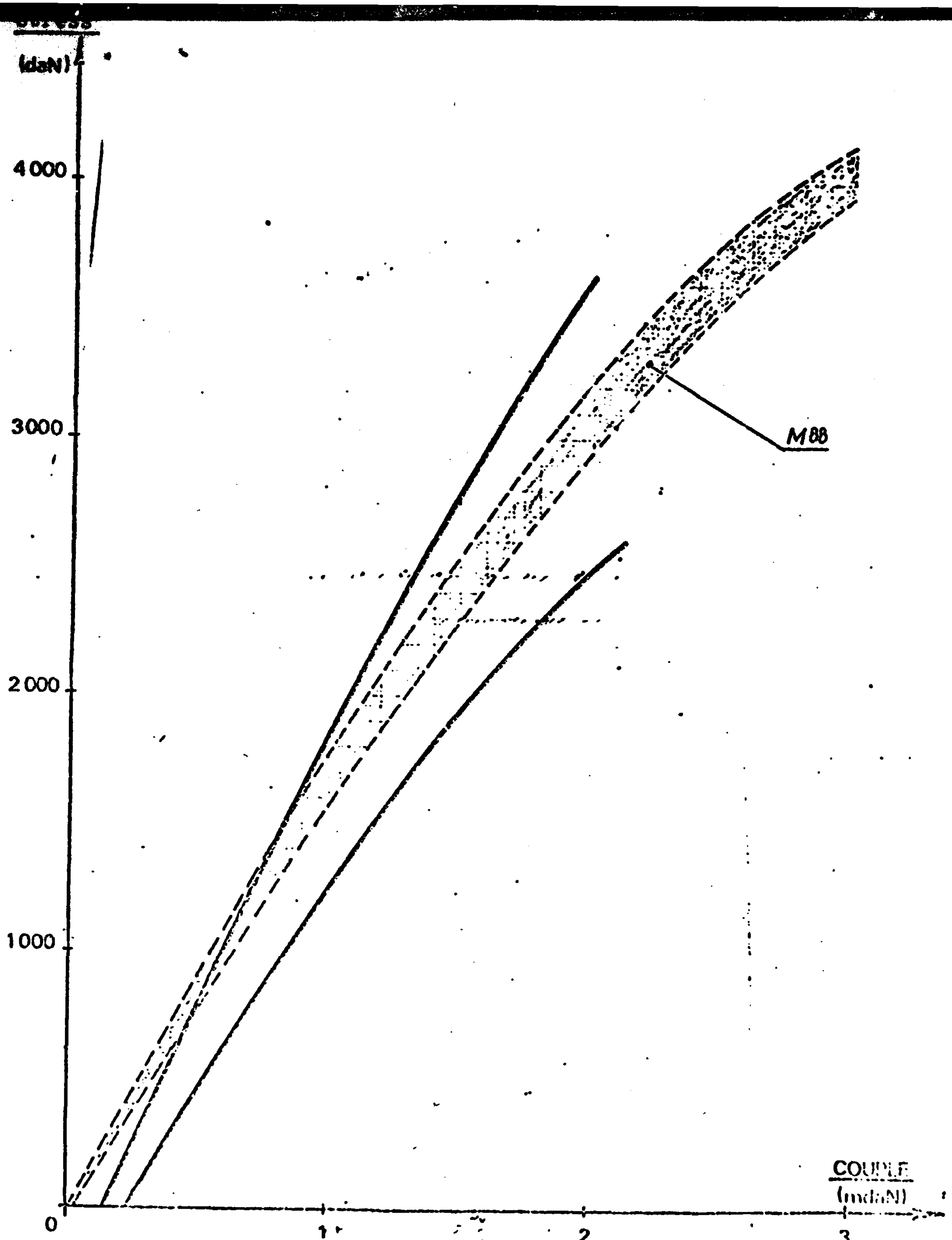
Couple-stress relationship: titanium screw Ø 6.35 protected with aluminum HI-KOTE 1, lubrication: cetyl alcohol; steel cadmium nut, lubrication: cetyl alcohol.



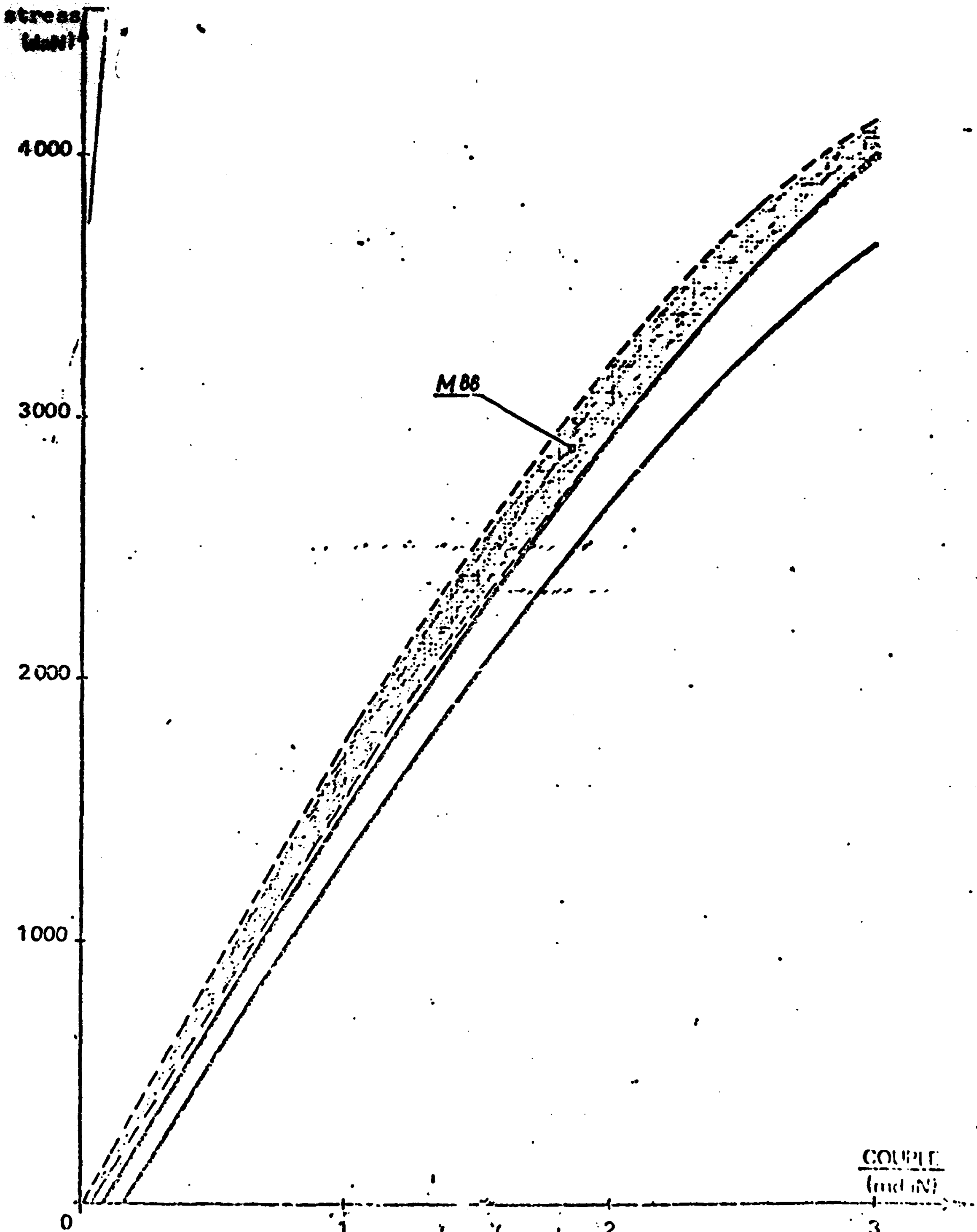
Couple-stress relationship for screw BAS 9082-5 (M88) with nut BAS 7094-5 (cetyl alcohol); screw: T-A6V Ø 7.94; nut: cadmium plated steel. Case of present usage.



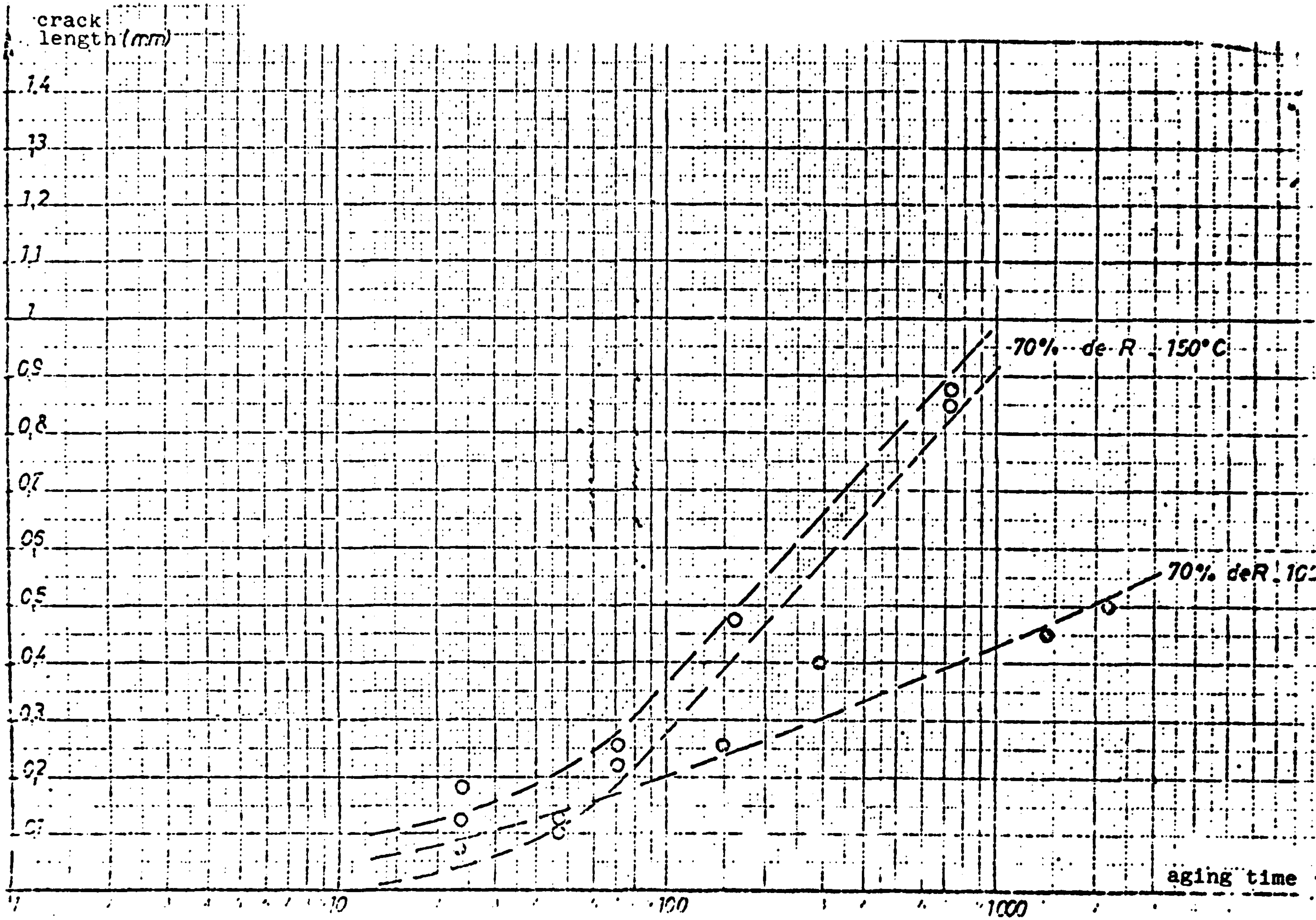
Couple-stress relationship for screw BAS 9082-5 (X 106) with nut BAS 7094-5 (cetyl alcohol); screw: T-A6V Ø 7.94; nut: cadmium plated steel.



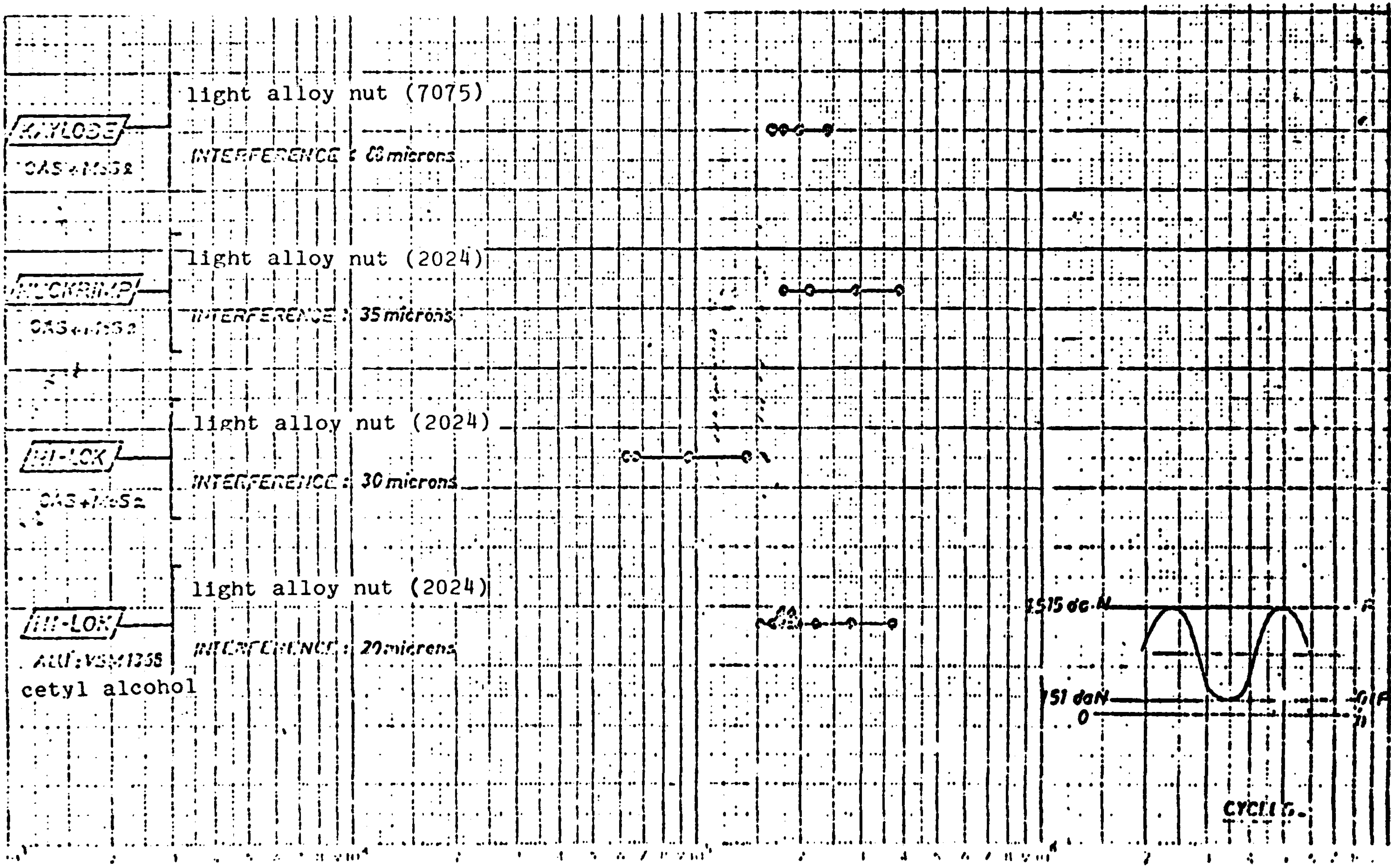
Couple-stress relationship for screw BAS 9082-5 (D81) bis) with nut BAS 7094-5 (cetyl alcohol); screw: T-A6V Ø 7.94; nut: cadmium plated steel.



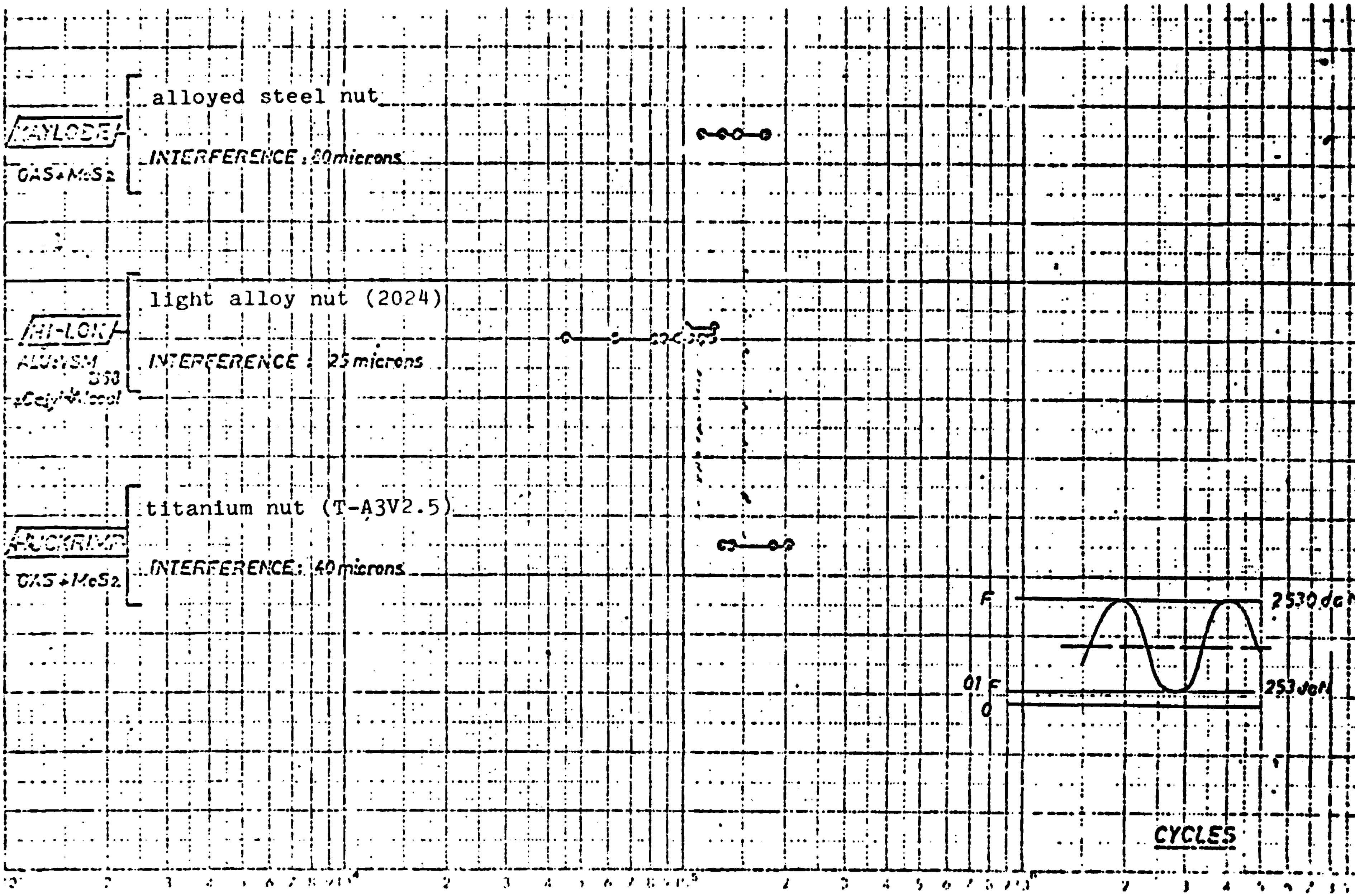
Couple-stress relationship for screw BAS 9082-5 (EMOS 60) with nut BAS 7094-5 (cetyl alcohol); screw: T-A6V Ø 7.94; nut: cadmium plated steel.



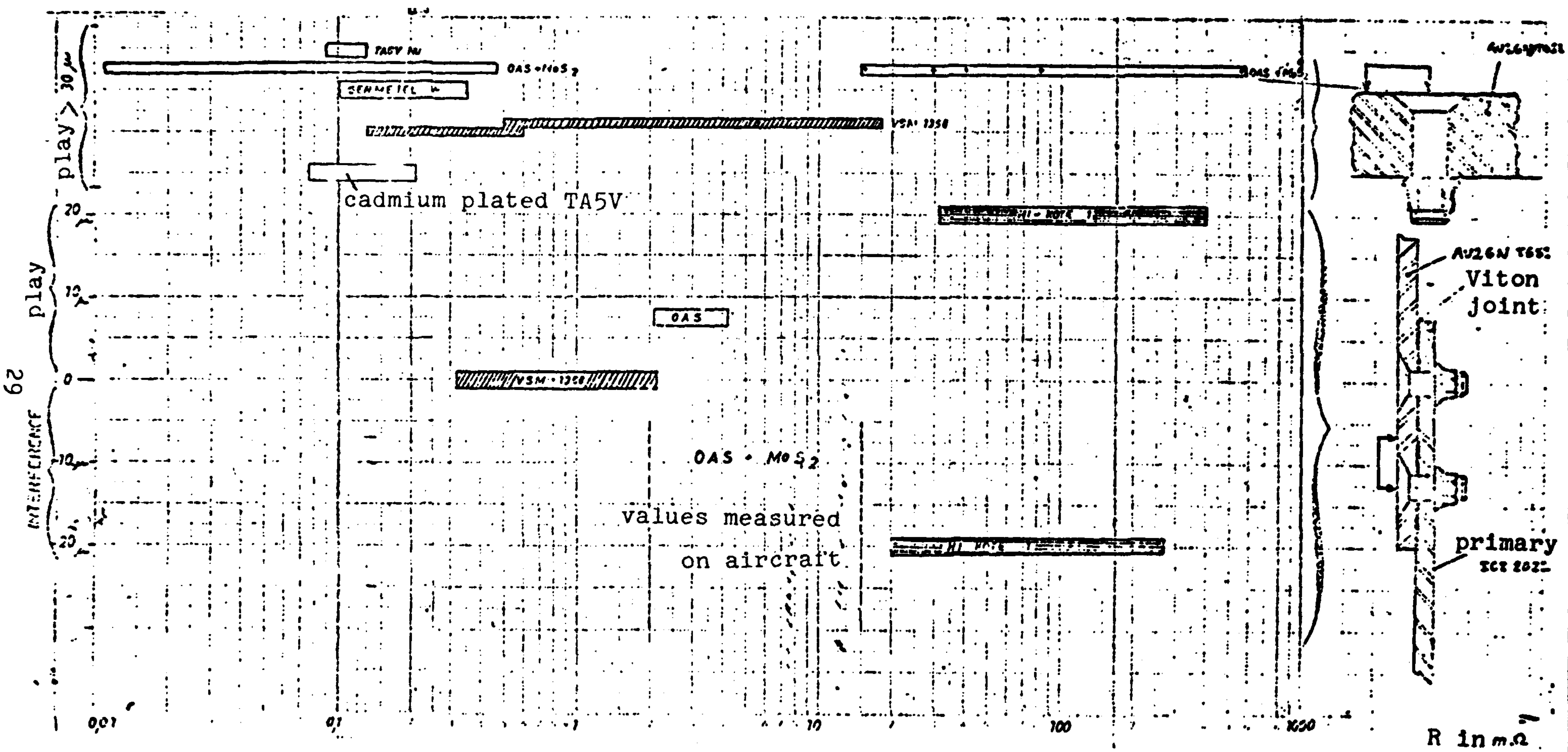
Weakening of titanium by cadmium plating; crack length as a function of time and temperature.



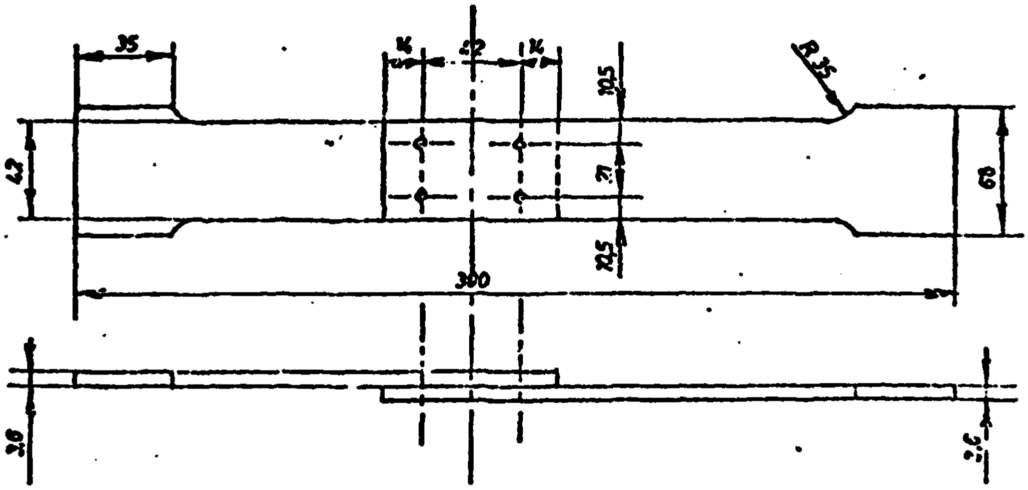
Fatigue tests for type D (Ø 4.8) assemblies.



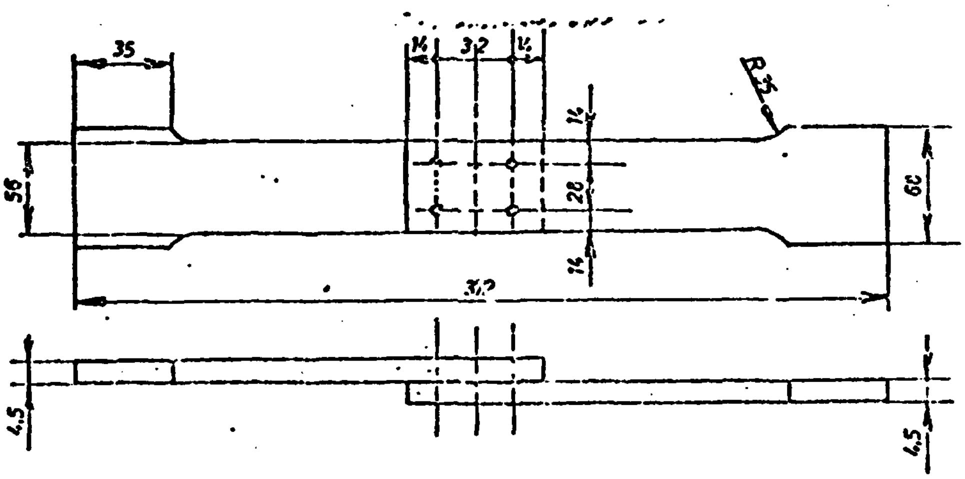
Fatigue tests for type G assemblies (Ø 6.35).



Measurement of contact resistance.



TYPE "D" Ø 4,8 (d/e : 1,32)

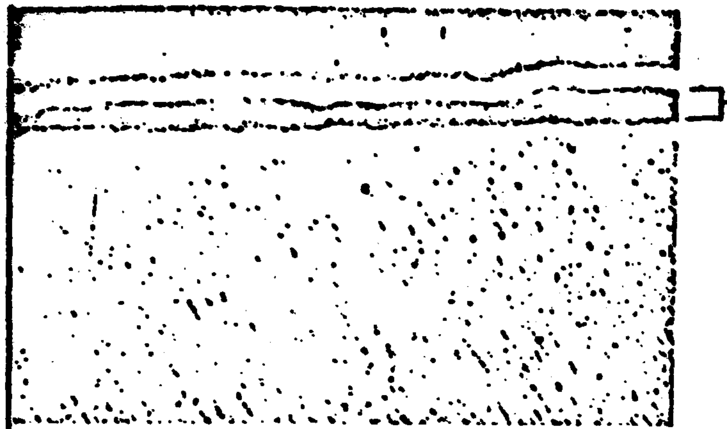


TYPE "G" Ø 6,35 (d/e : 1,41)

Samples for dynamic tests.

Material- AU2GNT851; protection- Alodine 1200; paint- primary Epoxy ICI2022; Insert Viton.

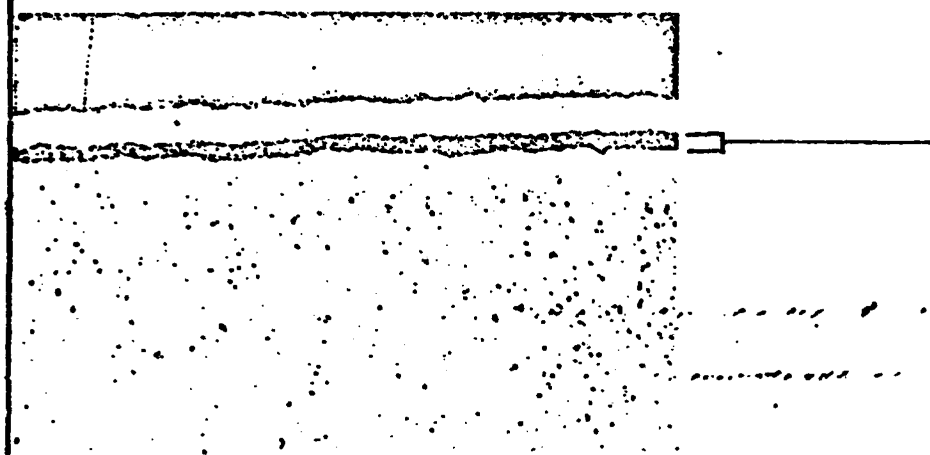
Plate 1



VSM 1368

e = 15 to 20 microns

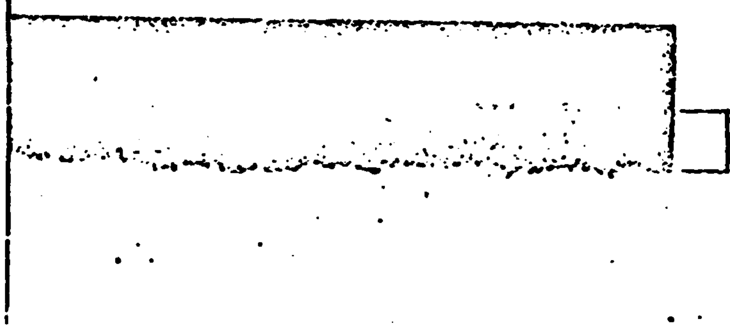
Photo No. 16.445
G X 200



VERTEC

e = 4 to 5 microns

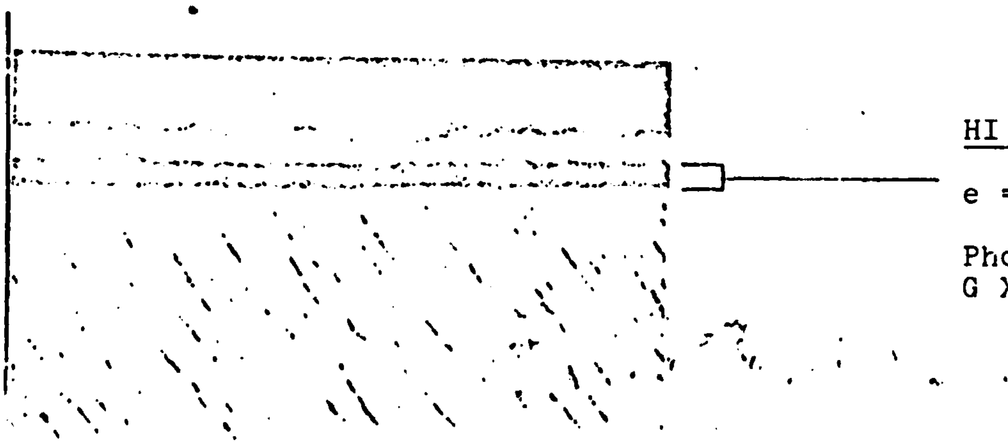
Photo No. 16.452
G X 200



SERMETEL W

e = 40 microns

Photo No. 14.963
G X 200



HI KOTE 1

e = 10 to 15 microns

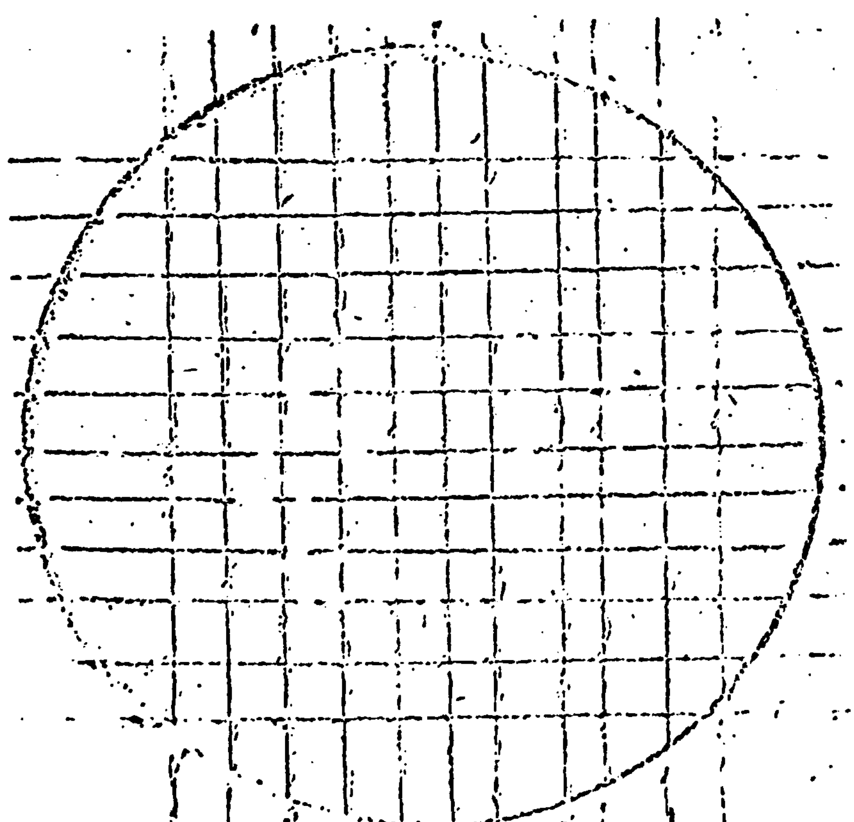
Photo No. 16.450
G X 200

Thickness of the aluminum protection.

Plate 2

on SERMETEL W 100%

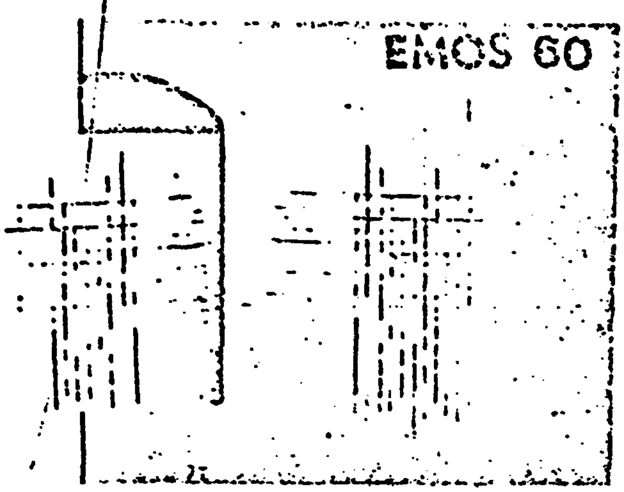
Photo No. 3447



on VSM 1368 100%

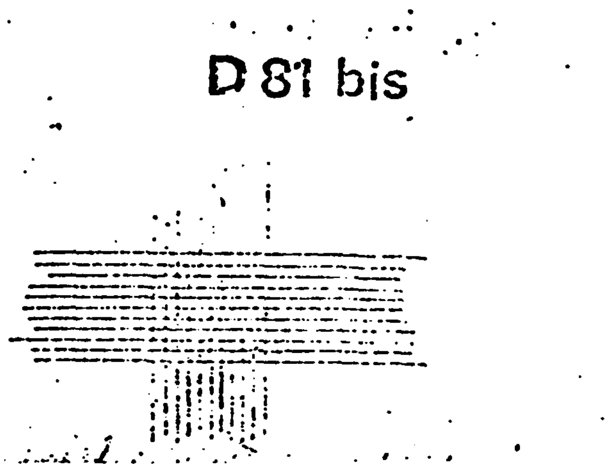
Photo No. 3446

Adherence of paint.



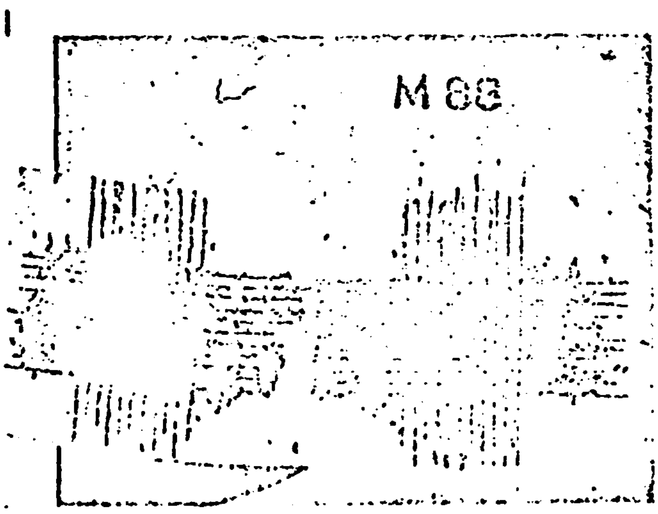
Adherence 100%

Photo No. 3461



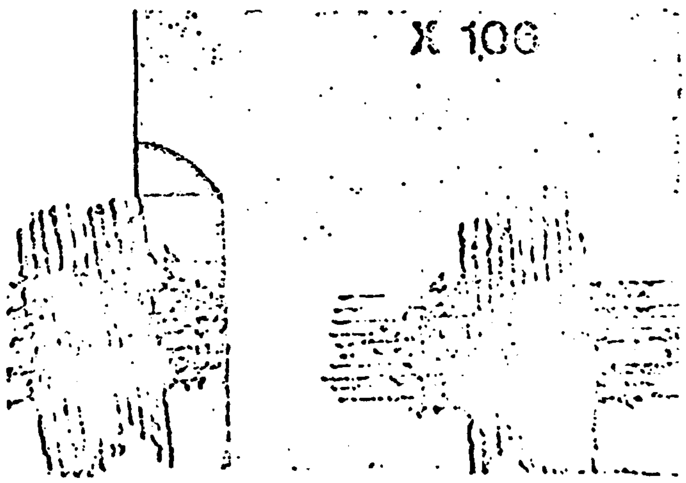
Adherence 100%

Photo No. 3722



Adherence 0 to 15%

Photo No. 3460



Adherence 0 to 20%

Photo No. 3462

Adherence of paint.

Plate 4

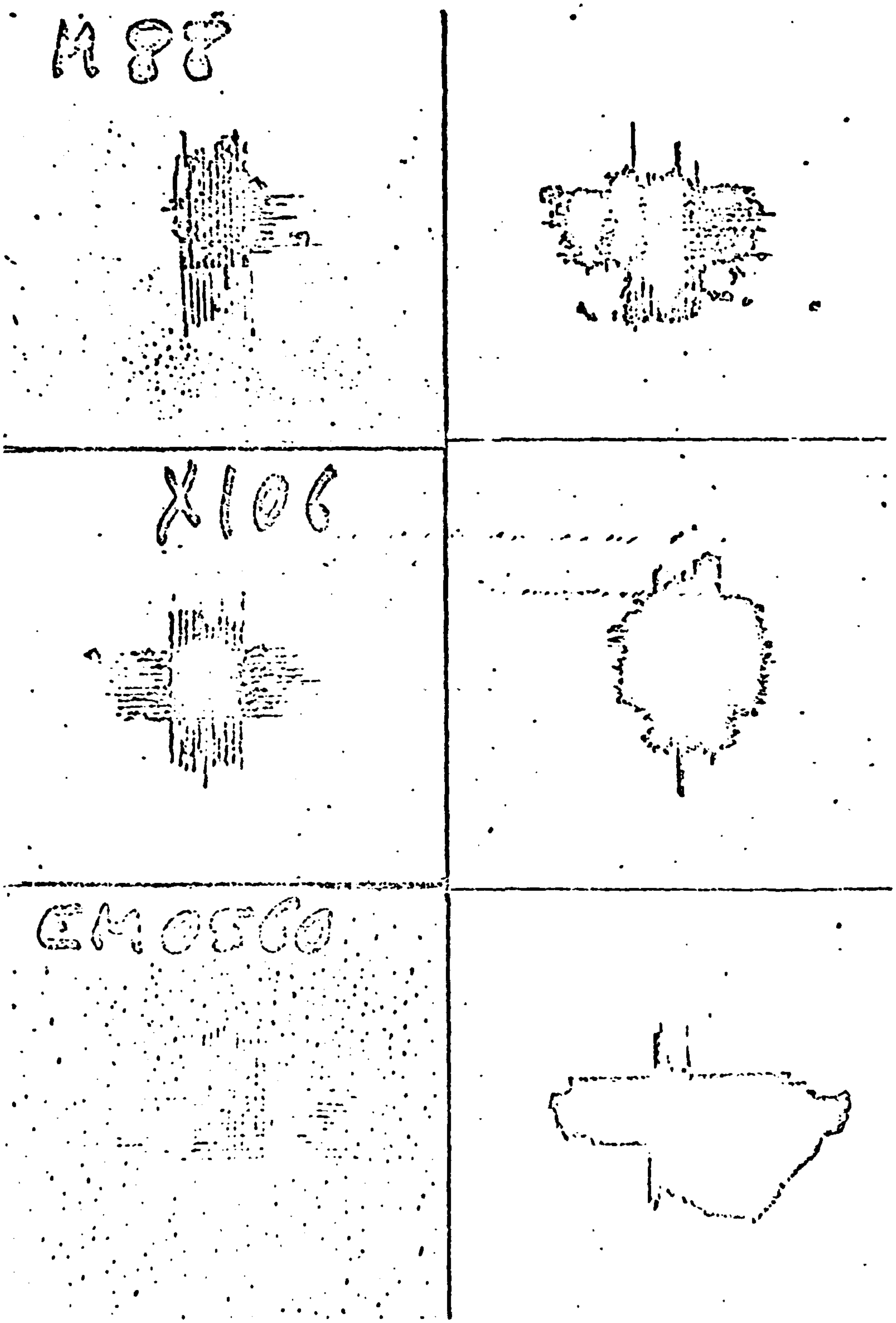
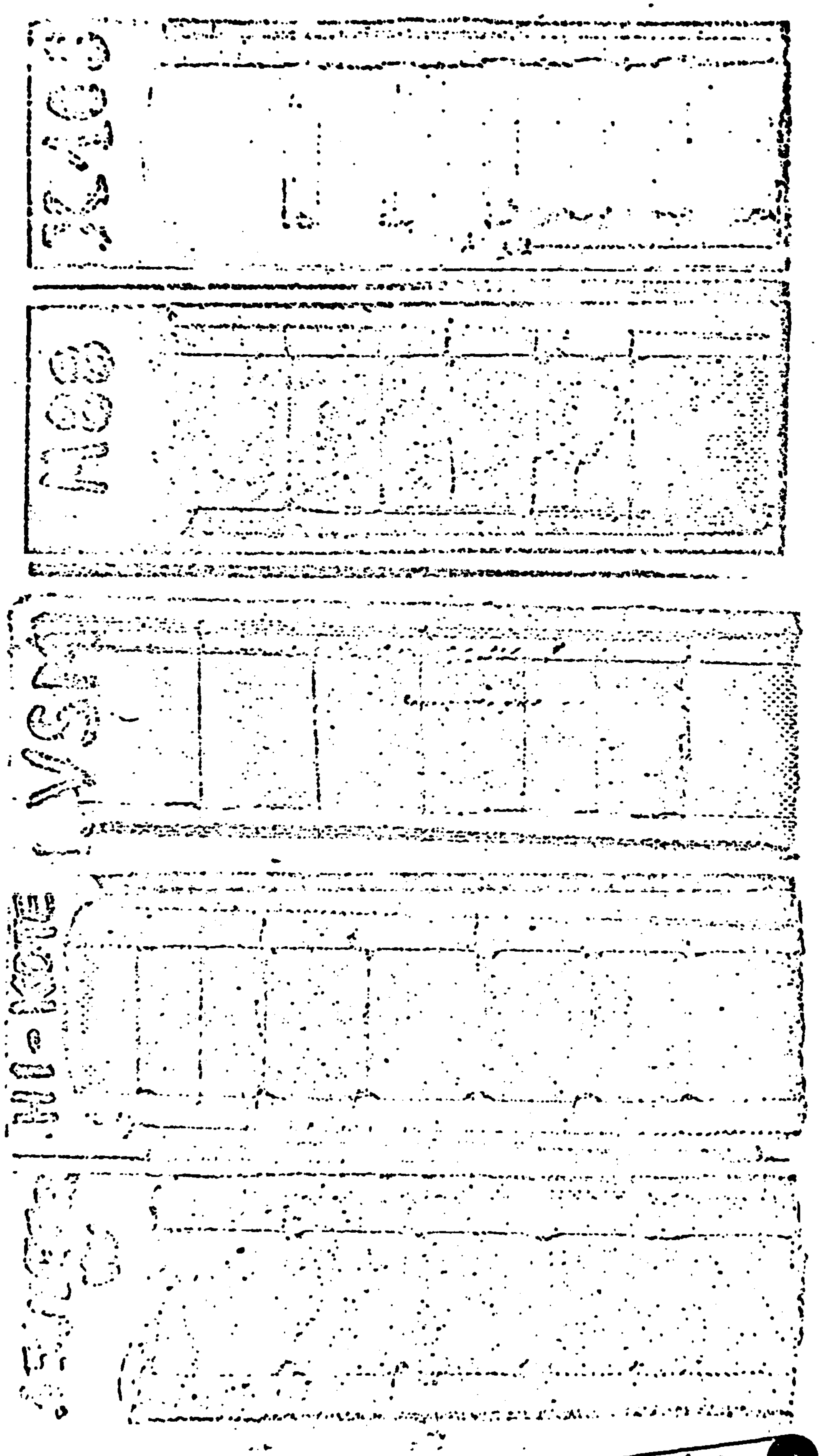


Photo No. 3665

Adherence of paint before and after aging in the humid oven (750 hours at 40° C and 98% HR).

Plate 5



Adherence of PR 1431 (photo No. 4127).

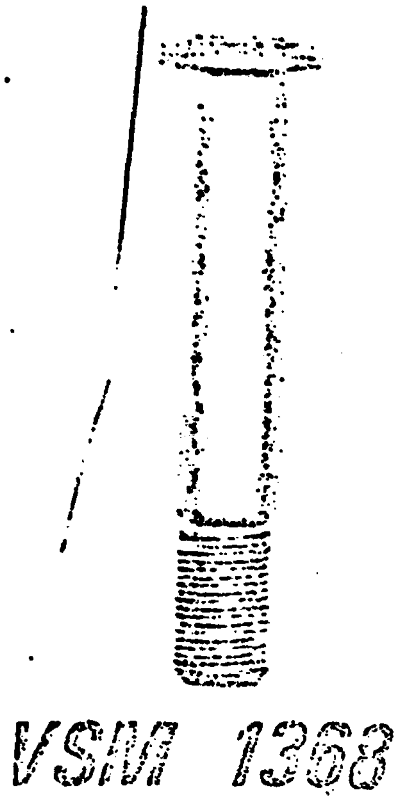


Photo No. 4102 "V".

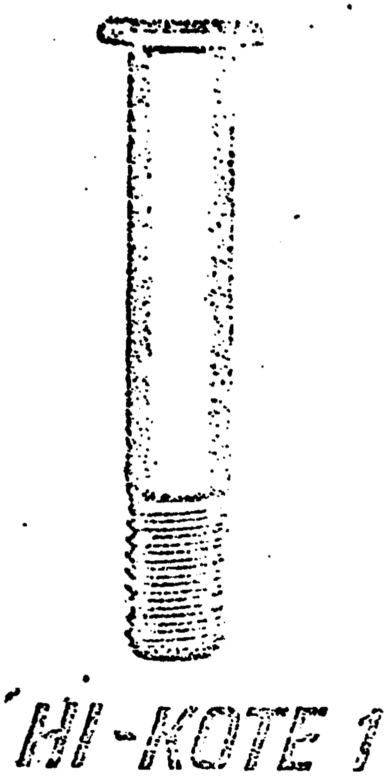


Photo No. 4102 "H"

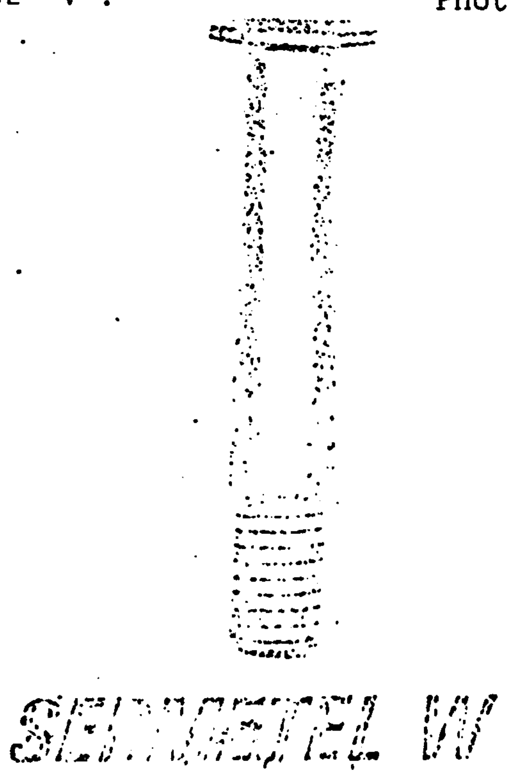
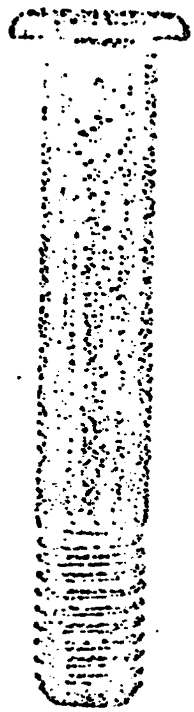
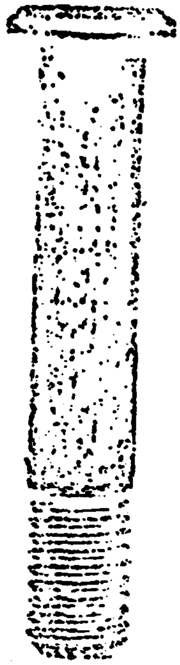


Photo No. 4102 "S"

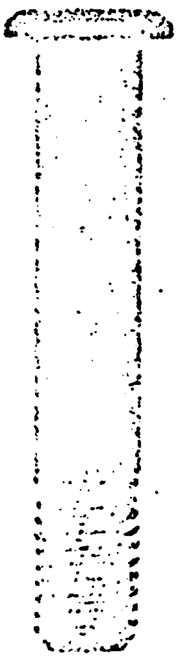
Aluminum protection, state of surface.



Screw SERMETEL W
Photo No. 4128



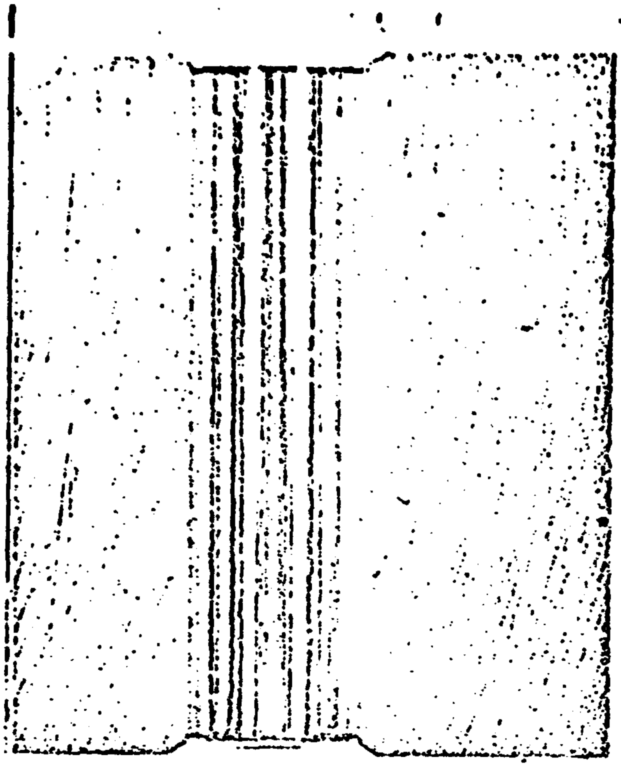
Screw VSM 1368
Photo No. 4129



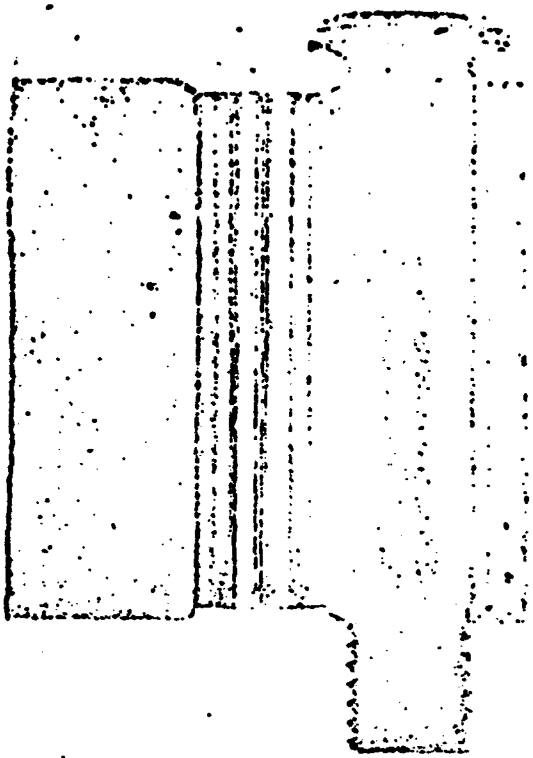
Screw HI KOTE 1
Photo No. 4130

Fitting tests. Surface state after assembly and disassembly.

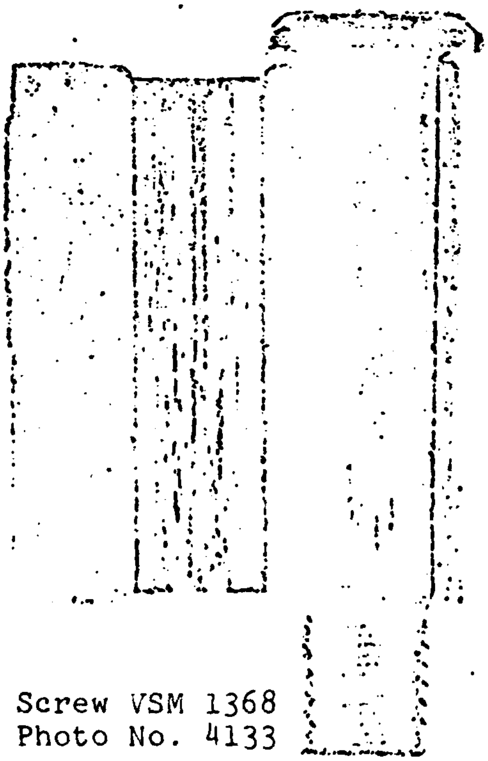
Plate 8



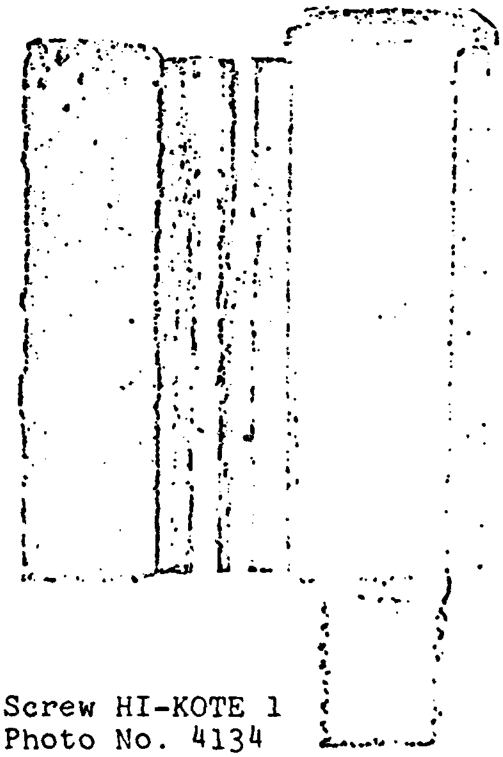
Original drilling
Photo No. 4131



Screw SERMETEL W
Photo No. 4132

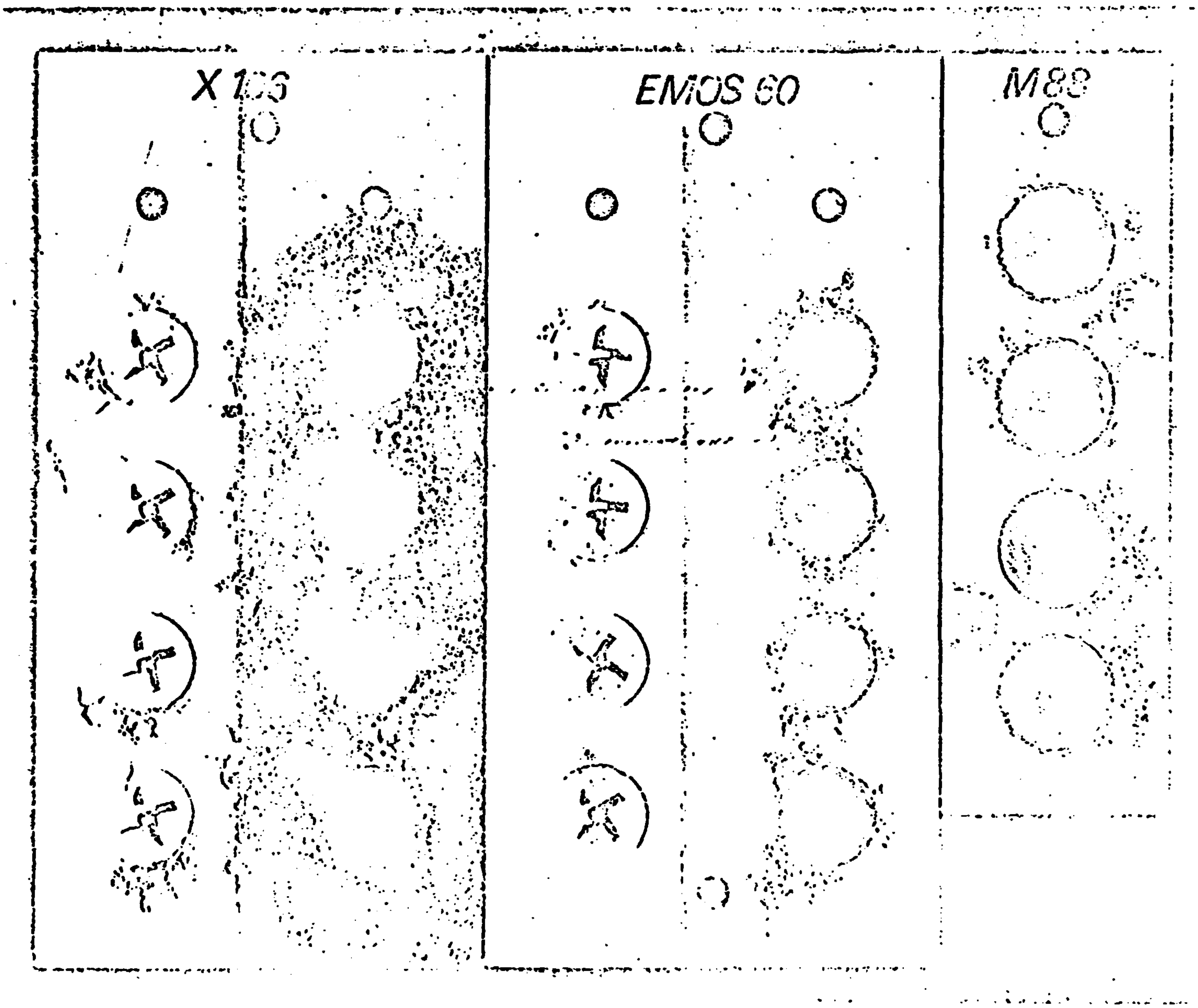


Screw VSM 1368
Photo No. 4133



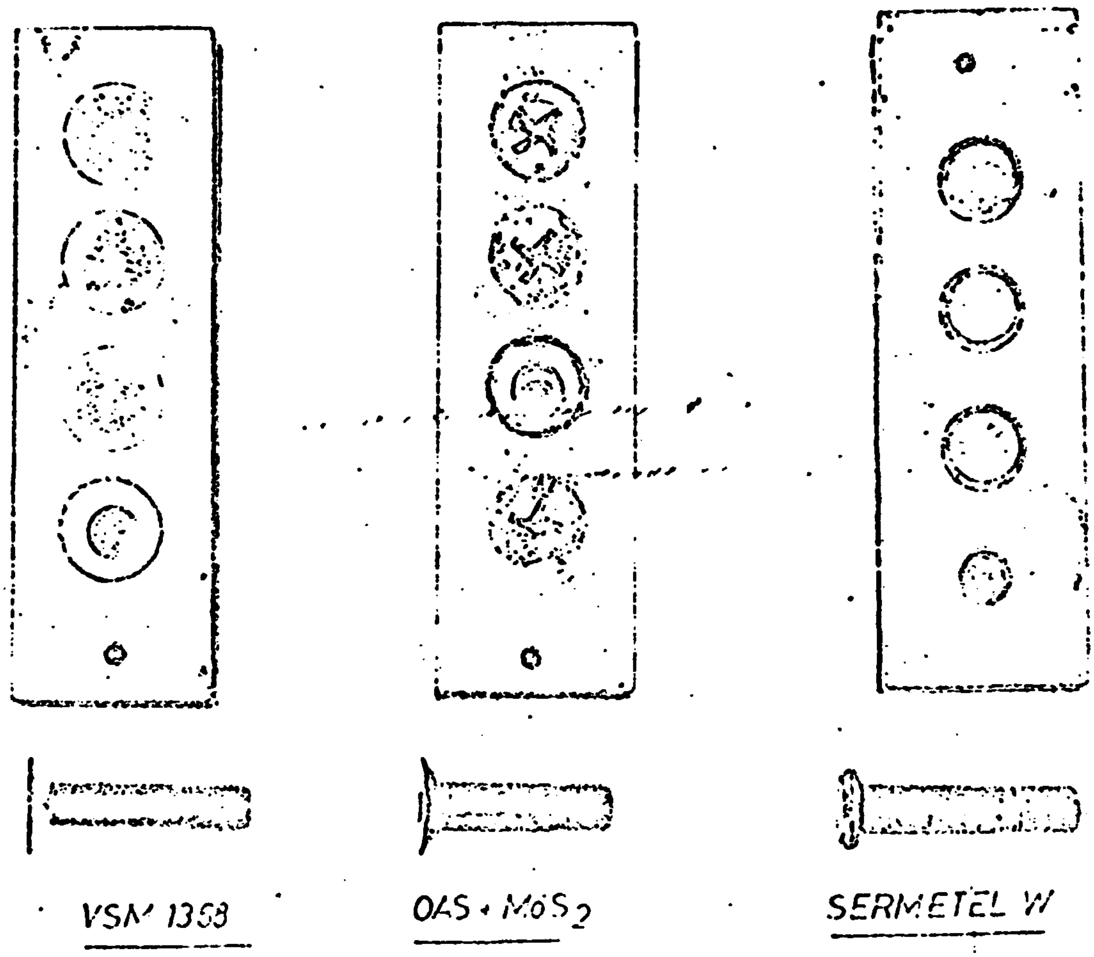
Screw HI-KOTE 1
Photo No. 4134

Fitting tests, surface state.

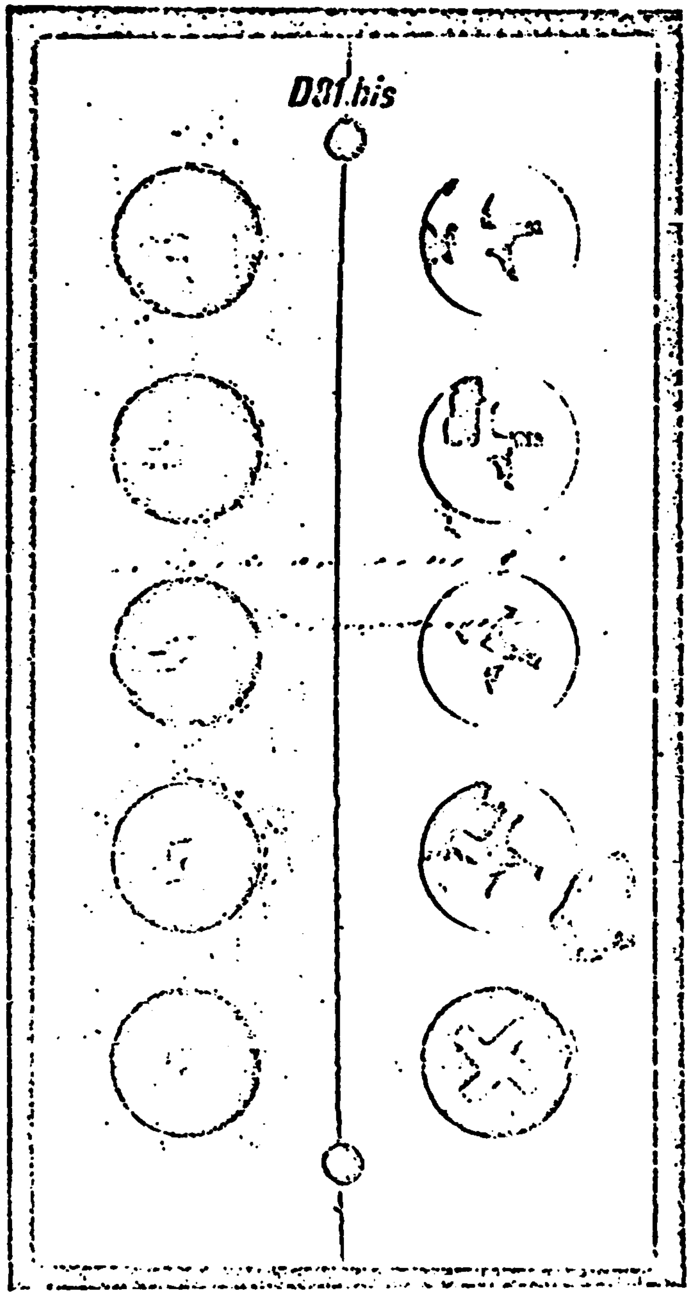


Saline vapor corrosion, 1500 hours (plate No. 3666).

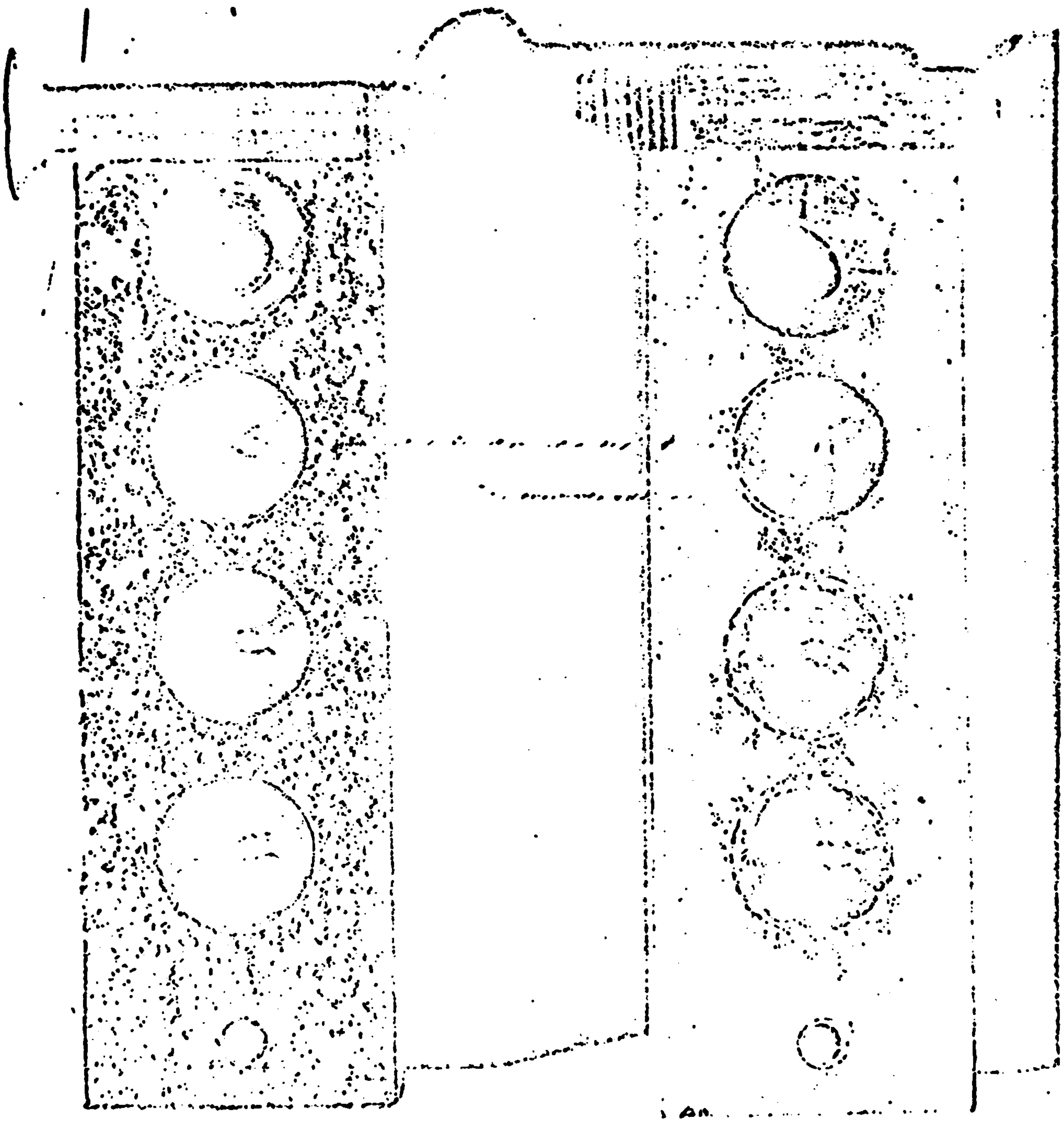
1500 hour aging in saline vapor



Saline vapor corrosion, 1500 hours (photo No. 3359).



Saline vapor corrosion, 1500 hours (photo no. 4126).

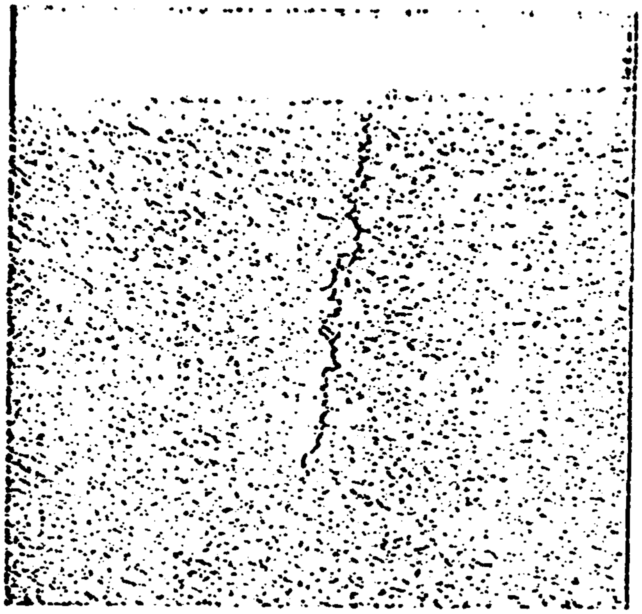


Block A-U2GN T6 Nu

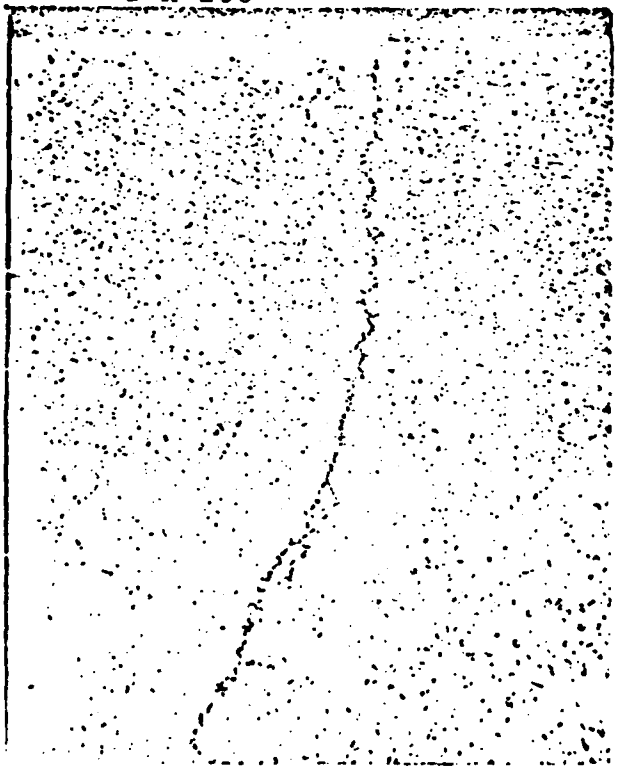
Block A-U2GN T6 with primary paint ICI 2010

Saline vapor corrosion, 1500 hours (photo No. 4156).

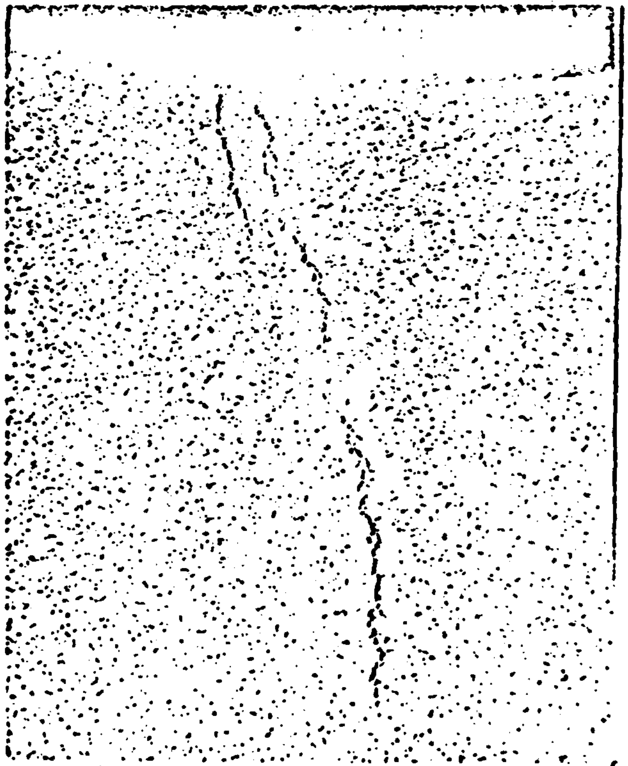
24 hour aging
photo No. 15.466
G X 200



72 hour aging
photo No. 15.467
G X 200



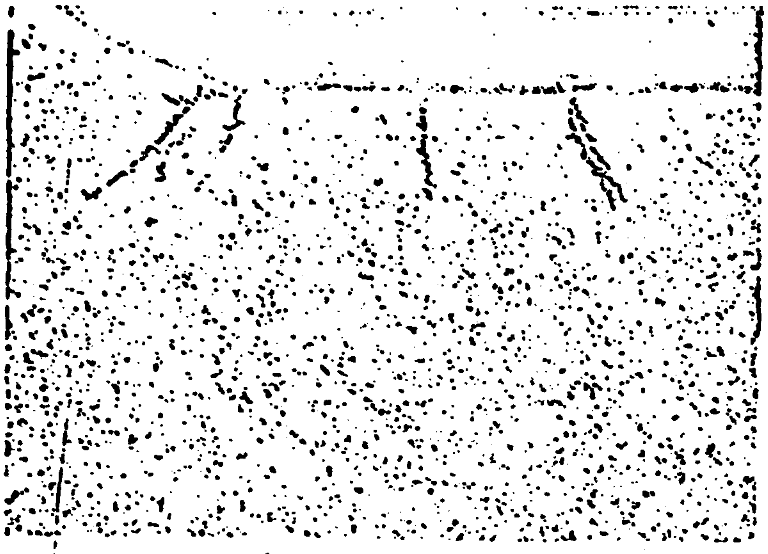
1 week aging
photo No. 15.468
G X 200



1 month aging
photo No. 15.469
G X 200

Weakening tests of T-A6V by cadmium plating, test conditions 70% of R at 150° C.

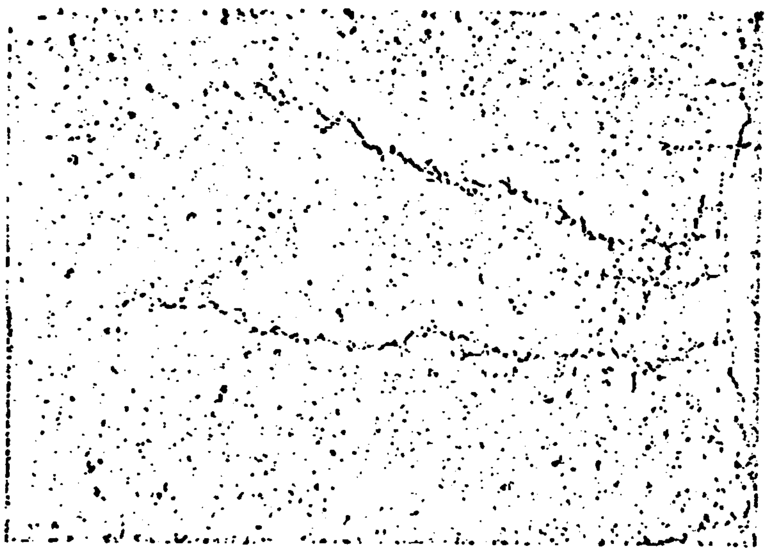
Plate 14



1 week aging

photo No. 16.629

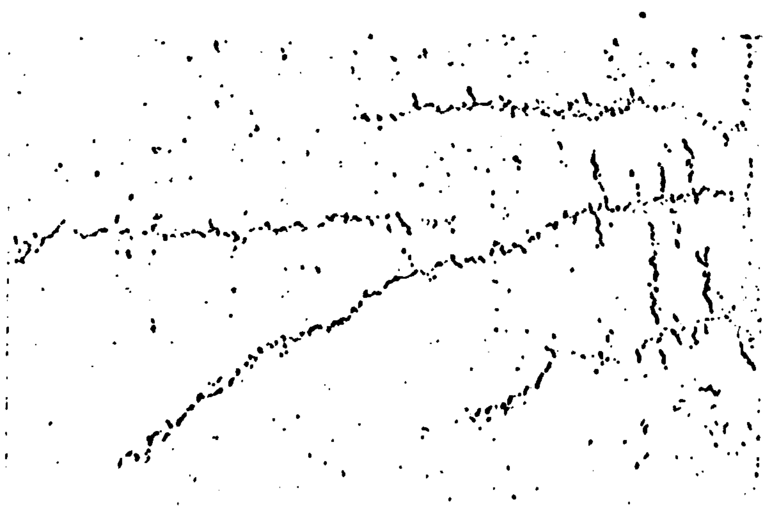
G X 100



15 days aging

photo No. 16.630

G X 200



2 month aging

photo No. 16.631

G X 200

Weakening of cadmium plated screw T-A6V, test condition 70% of R at 100° C.